NIAGARA RIVER
BIOMONITORING STUDY
1987

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FOREWORD

Environment Ontario's biomonitoring of contaminant sources along the Niagara River in 1987 has been produced as background information for the development of the Niagara River Remedial Action Plan (RAP) currently under preparation. Some of the data collected from this study has also been previously issued in the form of a news release (May 1988) and included in Appendix A of the 1989 IJC Great Lakes Water Quality Board Report (State of the Lakes).

This report also supports the Ministry's commitments to the Niagara River Toxics Management Plan.

Information provided by this study has also led to a 1989 follow-up investigation of selected sources along the Niagara River.

ACKNOWLEDGEMENTS

This study was requested by the Niagara River Improvement Project Office of the Ministry of the Environment as a follow-up to the recommendations of the Niagara River Toxics Committee Report (NRTC, 1984) and to fulfil monitoring commitments under the Niagara River Toxics Management Plan (1987).

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EXECUTIVE SUMMARY

Environment Ontario has used introduced (caged) mussels and indigenous algae (Cladophora) in biomonitoring studies in the Niagara River since 1980. Results from these studies have shown that most contaminant sources are located along the shore of the upper river on the American side.

A comparison of contaminant concentrations in mussel tissue, leech tissue and Cladophora from the river in 1987 with those in Lake Erie permitted the identification of areas of input and bioavailability of organic compounds. The data for mussels, leeches and Cladophora show that the majority of contaminants detected were found on the U.S. side of the river at Pettit Flume in North Tonawanda, 102nd Street and Love Canal landfill sites, Occidental's Buffalo Avenue plant (sewer 003), the mouth of Gill Creek and Bloody Run Creek. The highest concentration of most contaminants in biota were usually found at sites located at the Occidental sewer 003 outfall and 102nd Street hazardous waste site.

Based on this study, in most cases the contaminants were released from sources (point and non-point) in the Niagara River rather than from upstream sources in Lake Erie.

A summary of the contaminants found is as follows:

-PCBs (polychlorinated biphenyls), chlorinated benzenes and most of the organochlorine pesticide concentrations in mussel tissues were below the level of detection at all stations on the Canadian side of the Niagara River and at the Lake Erie control site, with only a few exceptions.

- PCBs were detected in mussels at all U.S. stations above Niagara Falls, with mussels from Gill Creek and Occidental's sewer 003 site having the highest concentrations.

- Occidental's sewer 003 was the only site where mirex was detected in exposed mussels.

-The metabolites of DDT, p,p'-DDD and p,p'-DDE were present in mussels at most stations in trace amounts which likely represents the historical widespread use for agricultural practices.

- Mussels at the mouth of Gill Creek had significantly higher concentrations of octachlorostyrene and hexachlorobutadiene compared with those from other stations. Trace concentrations were detected in samples from most U.S. sites but were not found in mussels at the Lake Erie control site or in mussels exposed on the Canadian side of the river. This suggests the Niagara Falls, New York area as a source of these contaminants.

- Mussels exposed at the Pettit Flume in North Tonawanda had significantly higher concentrations of hexachlorobenzene (HCB) compared with all other sites. Pettit Flume is likely an important source of chlorinated benzenes since many of the compounds were detected in mussels only at this station.

- Mussels exposed at Two Mile Creek (Tonawanda), Pettit Flume and Occidental's sewer 003 (Niagara Falls) had the highest concentrations of PAHs. Based on concentrations of PAHs in downstream sites, there is some evidence to suggest migration of these compounds.

- 2,3,7,8 TCDD was present in mussels only at the Pettit Flume (200 pg/g) and in sediments at Pettit Flume, Wheatfield and 102nd Street sites. Pettit Flume consistently had the highest concentrations of Chlorinated dioxins and furans in both mussels and sediment and is likely an important source to the river.

- The highest mean concentration of chlorinated phenols (CP) in leeches were detected at Pettit Flume. All of the U.S. sites are indicated as active sources as well as Frenchman's Creek (Canadian Side).

- Locations of elevated contaminant levels in mussels agreed with information on known or suspected sources and correlated with the spatial differences observed in residue levels of indigenous biota (Cladophora & spottail shiners) from the river.

The highest mean concentrations of PCBs, HCB, mirex, 1,2,3 trichlorobenzene, 1,2,3,4 tetrachlorobenzene and pentachlorobenzene were found in Cladophora collected from the same stations where the highest concentrations were found in mussels. Similar results for some contaminants were seen in spottail shiners.

Recommendations for future study:

- Investigate and eliminate sources of persistent contaminants to the Niagara River.

- The length of time for mussels to reach equilibrium for specific contaminants is still not known, accordingly, further research should continue. This is not required to meet the objectives of this study (i.e. presence/absence of the contaminant), however, if we want to assess the variability associated with the specific contaminant concentrations of the effluent both temporally and spatially, then we have to know when the biomonitor has reached equilibrium. It is known that the concentration of contaminants discharged to the Niagara River at specific sources is not consistent, accordingly, we have no way of determining if the concentrations found in exposed mussels reflects the concentration discharged to the river.

- A regular biomonitoring program should be maintained every 2 years to allow significant trends to be detected.

- Future studies should increase the range of sampling stations to represent open water conditions rather than only sampling at the shoreline to augment the Niagara River Toxic Management Plan monitoring program.

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INTRODUCTION

Aquatic biota can accumulate and integrate contaminants which may be either introduced sporadically into the environment or occur in water at levels below current analytical detection limits. The determination of contaminant levels in aquatic biota in the Niagara River provides valuable information for identifying areas of contamination and sources, as well as the potential bioavailability of contaminants in the aquatic environment.

Numerous persistent toxic and bioaccumulative contaminants from industry and waste disposal sites along the Niagara River, as well as their possible impact on water use, have been the subject of increasing concern in recent years. Freshwater mussels (Elliptio complanata), filamentous algae (Cladophora glomerata) and young forage fish (Notropis hudsonius) have been routinely monitored on the Niagara River since 1980. Much of the information collected led to the conclusions and recommendations of the Niagara River Toxics Committee Report (NRTC, 1984). The use of leeches (Nephelopsis obscura) as biomonitors for chlorinated phenols on the Niagara River was initiated in 1987.

The 1987 biomonitoring study was designed to provide an update to previous surveys (1980, 1981, 1983, 1985) and identify the potential of other sites and tributaries to contribute contaminants to the Niagara River. Mussels and leeches collected from uncontaminated inland lakes were placed in the Niagara River in cages at specific locations, and resident Cladophora and bottom sediments were collected for the following specific objectives:

- identify contaminant sources or source areas requiring more detailed follow-up investigations based on uptake of contaminants in selected biomonitors
- compare these results with ongoing long-term trace contaminant monitoring with indigenous species (spottail shiners, Cladophora) and identify spatial and temporal trends
- augment ongoing upstream/downstream Niagara River Toxics Management Plan programs (NRTMP, 1988) by providing information on contaminant levels in the river between Fort Erie and Niagara-on-the-Lake.

METHODS

Mussels

Elliptio complanata is found in the southern James Bay drainages and the St. Lawrence system, with the exception of Lake Huron south of Georgian Bay, Lake Michigan, and most of Lake Erie. This species lives in shallow water of permanent lakes, rivers and streams, and is found on gravel, sand, or mud bottoms (Clarke, 1981).

Elliptio complanata grows to about 125mm long, 65mm high, and has a shape that is somewhat trapezoidal or elliptical, with a rounded posterior ridge. The colour of this type of mussel is brownish or blackish and unrayed except in some young specimens and in adults from sandy substrates. The annual growth rings are also well marked on the mussel. The nacre (pearly inner side of shell) is purple in most specimens, but can be pinkish or whitish in others (Clarke, 1981).

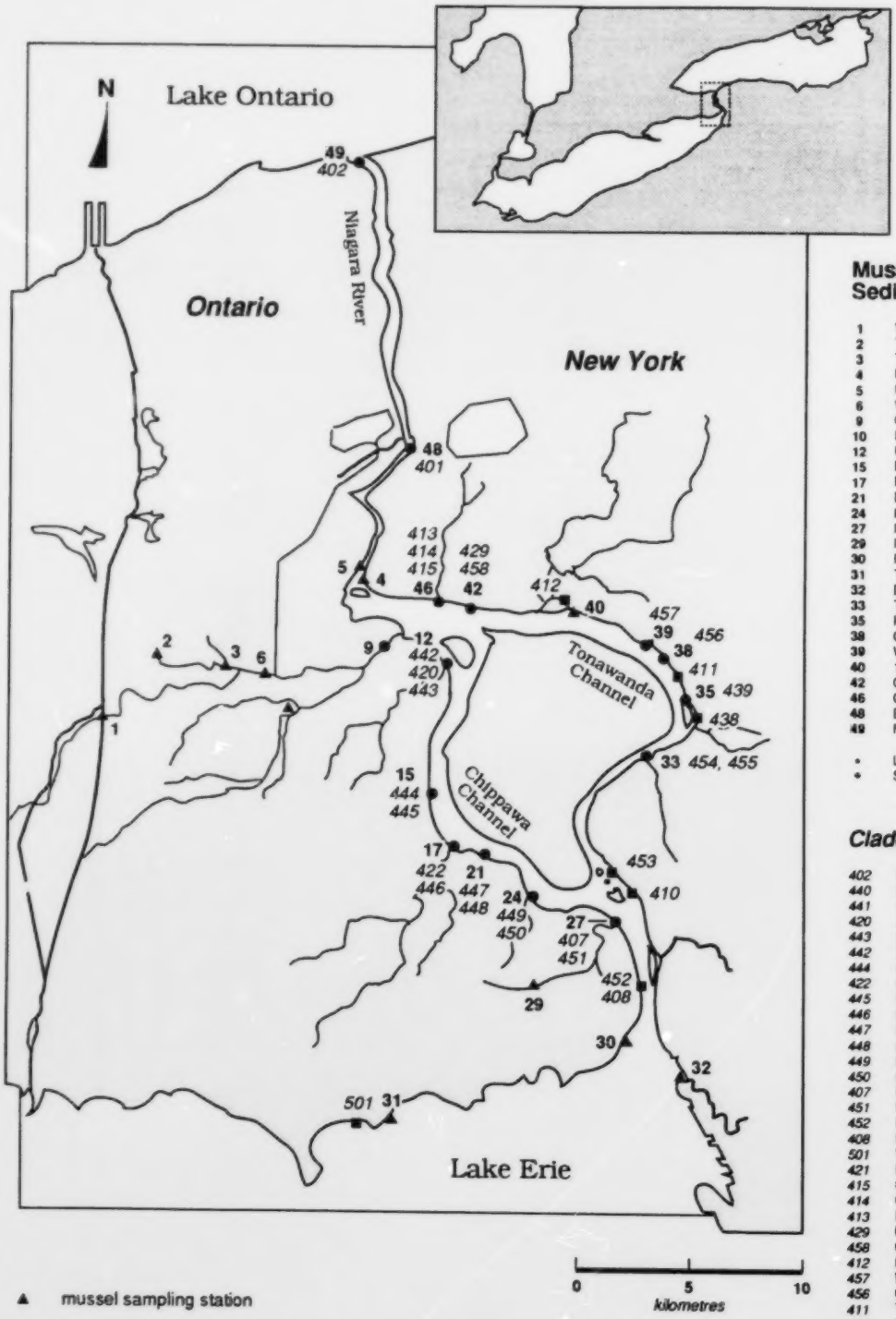
On June 20, 1987 mussels for the biomonitoring study (between 65mm and 72mm in length) were collected from Balsam Lake (Victoria County), Ontario, a relatively clean source by snorkelling. The mussels were placed in a bucket lined with clean bioassay (food-grade) bags partially filled with lake water. The bags were sealed with air trapped inside and rapid temperature fluctuations were avoided. For transportation to the study area, the air in the bags was displaced with oxygen. As part of Environment Ontario's regular program, mussels from the Balsam Lake collection were submitted to the laboratory for analysis to ensure that contaminants were at low background concentrations.

On June 23, 1987, at each of 27 monitoring stations (Figure 1), five mussels were placed in each of three envelope-shaped cages (30 x 45 cm constructed of 1.25 cm galvanized mesh poultry netting). The cages were secured with nylon rope to a concrete block and set upon the river bottom in a location which would likely not be disrupted during the course of the study. Bioaccumulation data collected from mussels has shown that there is no significant difference in uptake when the mussels are placed in the water column or on the bottom (Shadford, 1989).

After an exposure period of 21 days, the mussels were retrieved. Data collected by OMOE and others, suggest that for many of the contaminants of concern, three weeks is an adequate period to achieve or to at least approach equilibrium provided that exposure concentration is kept constant (Kauss and Angelow 1988, Hayton *et. al.*, 1990). However, for some compounds such as octachlorostyrene, 2,3,7,8-TCDD, mirex and the more hydrophobic species of PAHs, the time period to achieve equilibrium is more likely to be in the order of months rather than weeks (Russel and Gobas, 1989; Hayton *et. al.*, 1990).

Figure 1

Niagara River biomonitoring stations, 1987



▲ mussel sampling station

■ *Cladophora* sampling station

● common location of mussel and *Cladophora* station

Mussels, Leeches and Sediment Stations

1	Welland R. near airport *
2	Thompsons Cr. at Cyanamid Can. Inc.*
3	Thompsons Cr. (mouth)
4	Falls St. Tunnel *
5	Maid-of-the-Mist Pool *
6	Welland at Power Canal *
9	Chippawa Cr.
10	Lyons Cr.
12	Usshers Cr.*
15	Boyers Cr.*
17	Black Cr.*
21	Baker Cr.*
24	Miller Cr.*
27	Frenchmans Cr. * *
29	Frenchmans Cr. at Durez *
30	Fort Erie at Robertson St.*
31	Thunder Bay
32	Buffalo R. * *
33	Two Mile Cr.
35	Pettit Flume * *
38	Gratwick / Riverside Park *
39	Wheatfield * *
40	102nd St.*
42	Occ. Sewer 003
46	Gill Cr.
48	Bloody Run Cr.
49	Niagara-on-the-Lake *

* Leech sampling stations
* Sediment sampling stations

Cladophora Stations

402	Fort George
440	Pell Cr.
441	Lyons Cr.
420	Usshers Cr. (mouth)
443	Usshers Cr. (instream)
442	Usshers Cr. (control)
444	Boyers Cr. (mouth)
422	Boyers Cr. (control)
445	Black Cr. (mouth)
446	Black Cr. (control)
447	Baker Cr. (mouth)
448	Baker Cr. (control)
449	Miller Cr. (mouth)
450	Miller Cr. (control)
407	Frenchmans Cr. (mouth)
451	Frenchmans Cr. (control)
452	Fort Erie (North)
408	Fort Erie
501	Windmill Point (L. Erie)
421	Bloody Run Cr. (mouth)
415	Gill Cr. (mouth)
414	Gill Cr. (control)
413	Landfill North
429	003 Sewer
458	003 Sewer (control)
412	Love Canal
457	Wheatfield
456	Gratwick Riverside Park
411	Tonawanda
439	Pettit Flume (mouth)
438	Pettie Flume (control)
454	2-Mile Cr. (mouth)
455	2-Mile Cr. (control)
453	Black Rock Canal
410	Strawberry Is.

When retrieved, the mussels were immediately shucked, excess water was drained and the soft tissues were individually wrapped in hexane-rinsed aluminum foil for analyses of PCBs, organochlorine pesticides, chlorinated benzenes, polycyclic aromatic hydrocarbons (PAH) and chlorinated dioxins and furans. The samples were stored on ice during transport to the Environment Ontario laboratory in Rexdale, Ontario and then stored at -20 degrees C prior to analyses. Table 1 lists the parameters that were analyzed.

Table 1. Chemical analyses conducted on mussel and leech tissue.

Mussel tissue analyses:	Industrial Compounds/ Chlorinated Benzenes	PCBs/ Organochlorine Pesticides
	Hexachlorobutadiene	Total PCB
		Heptachlor
	2,3,6 Trichlorotoluene	Aldrin
	2,6,a Trichlorotoluene	Toxaphene
	2,4,5 Trichlorotoluene	Mirex
	1,2,4 Trichlorobenzene	α-BHC
	1,3,5 Trichlorobenzene	β-BHC
	1,2,3 Trichlorobenzene	γ-BHC
	1,2,3,4 Tetrachlorobenzene	α-Chlordane
	1,2,3,5 Tetrachlorobenzene	γ-Chlordane
	1,2,4,5 Tetrachlorobenzene	o,p'-DDT
	Pentachlorobenzene	p,p'-DDD
	Hexachlorobenzene	p,p'-DDT
	Octachlorostyrene	p,p'-DDE
	Hexachloroethane	
	Polychlorinated dibenzo-p-dioxins	
	Polychlorinated dibenzo furans	
	PAHs	
	Lipid(%)	
Leech tissue analyses:	2,3,4 Trichlorophenol	
	2,4,5 Trichlorophenol	
	2,4,6 Trichlorophenol	
	2,3,4,5 Tetrachlorophenol	
	2,3,5,6 Tetrachlorophenol	
	Pentachlorophenol	
	Lipids (%)	

Leeches

Approximately 500 specimens of the bait leech Nephelopsis obscura (F. Erpobdellidae) were purchased from a Toronto bait shop on June 19, 1987. The leeches were originally from a lake in Wisconsin or Michigan. Specimens were maintained in food-grade plastic lined buckets with 5 litres of water for transportation to the study area. The buckets were given a head of oxygen, which was renewed daily, and were stored at ambient temperature.

Leeches were selected as biomonitors for chlorophenols (Table 1) because studies have demonstrated that they have high bioconcentration capacities for these compounds (Metcalfe & Hayton, 1988).

Leech cages were cylindrical in shape, 35 cm long x 15 cm in diameter and were constructed by 10 x 10 mesh (10 spaces per linear inch) stainless steel wire cloth having a wire diameter of 0.064 cm and opening of 0.191 cm. The overlapping edges were woven together with stainless steel wire and the ends were capped with polyethylene plugs which had been presoaked in a cleaning solution to remove any soluble organic compounds. The plugs were secured with stainless steel gear clamps.

One cage containing between 40 and 45 leeches was deployed at each of 12 sampling station (Figure 1). Stations were located in areas suspected of being a source of chlorinated phenols as well as stations located at the head and mouth of the Niagara River. Cages were placed on the substrate along with the cages of mussels.

Leeches were exposed in the river for 21 days. When the cages were retrieved, three replicate samples (groups of 10 to 15) from each site were wrapped in hexane-rinsed aluminum foil and stored on ice during transport to the Environment Ontario laboratory in Rexdale. The samples were then frozen at -20 degrees C prior to analysis. Three groups of 10 - 15 control animals were also included with the laboratory submission.

Cladophora

Cladophora glomerata is a dominant attached filamentous green alga found throughout the nearshore of the Great Lakes. The proliferation of Cladophora is a basin-wide symptom of eutrophication in Lakes Erie and Ontario (Jackson, 1985). There are two major growth forms. The first, initiated each spring from overwintering holdfasts, grows below the waterline to a maximum depth of about 10 m. The second growth form is initiated during summer from spores released by the older submerged filaments and appears as a noticeable waterline "fringe" until freeze-up (Jackson, 1985). Because of their distinctive growth characteristics, widespread distribution and known capacity to concentrate contaminants (particularly inorganic contaminants), Cladophora is well suited to act as a biomonitor (Prosi 1979).

Cladophora samples were collected from 18 Canadian and 16 American shoreline sites on the Niagara River (Figure 1) from June 15 to 18, 1987 for determination of internal concentrations of organic contaminants; organochlorine pesticides, chlorinated benzenes and

chlorinated phenols as described in Table 1 for mussels and leeches. In addition, several other compounds were analyzed, however, all chlorinated benzenes and chlorinated phenols listed were not analyzed at every station (Appendix Table 1). Samples were also obtained from a control site on Lake Erie at Windmill Point. Approximately 1 kg (wet weight) of algae was collected at each site, washed with ambient water, squeezed dry, wrapped in absorbent paper and transported on ice to the Environment Ontario laboratory in Rexdale, Ontario. The samples were then freeze dried, ground and sub-sampled for analysis in triplicate.

Sediments

A separate sediment sample (upper 3 cm of sediment) was obtained using a Ponar sampler from each station where possible (12 stations) (Figure 1). If there was not enough material obtained from one grab, a composite sample was obtained. General sample composition (eg. sand, silt, etc.), sediment colour, any unusual features, and number of grabs in a composite were recorded. Samples were kept cool and dark until submitted to the Environment Ontario laboratory in Rexdale for PAHs and chlorinated dioxin and furan (five stations) analyses.

Site Selection

Site selection was based on: location of shore-based discharges; tributary inputs; areas along the U.S. shoreline known to contain hazardous wastes; and, previous sampling locations. Leeches were placed at only those locations which were known or suspected source areas of chlorinated phenolic compounds. Figure 1 shows the monitoring locations for all biota and sediments.

When cages were lost or the mussels/leeches had died, new ones were placed at those locations for an additional 21 days. Thompson's Creek below the Cyanamid Canada Inc. effluent discharge and at the point where the creek discharges to the Welland River, had 100% mussel mortality. The second exposure also had the same result. Ammonia levels in Cyanamid's effluent are the likely cause of death since the study also coincided with a plant shut-down when the flow was reduced and the concentrations of ammonia were higher in the water column than normally expected (D. Cunningham, personal communication, 1991), and the plant discharge forms a major component of the flow regime.

Analytical and Statistical Methods

Analyses of mussel and leech tissue, Cladophora and sediments followed the analytical techniques described in the Ontario Ministry of the Environment "Handbook of Analytical Methods for Environmental Samples" (Environment Ontario, 1983). Three replicate analyses on mussel and leech tissues were performed for each parameter which permitted statistical analysis of the data. The data were statistically analyzed using a one-way

ANOVA. If the one-way ANOVA indicated a significant difference among stations ($p < 0.05$), then a Tukey's Honestly Significant Difference (HSD) Test (Steel & Torrie, 1980) was performed to identify homogeneous groups ($p < 0.05$). For data points less than the detection limit (for mussels and leeches), a value of one-half of the detection limit was used in the analysis. Means calculated in this manner are flagged by an asterisk in Tables 2 to 4 and 7.

The Cladophora and sediment results were used to support the findings from the introduced biomonitors. Values in Table 8 and 9 preceded by a "<" sign indicate that the mean is composed of at least one "trace level" value. Trace is defined as a value between the Lowest Reportable Value (LRV) and the Reliable Measurable Value (RMV). The RMV is ten times the LRV.

RESULTS AND DISCUSSION

Chemicals that are not mentioned in the Results section were not found (less than method level detection for all replicates at all stations).

Mussels

PCBs and Organochlorine Pesticides

With the exception of the upstream control stations and the downstream station at Niagara-on-the-Lake, sampling stations were located either in tributaries or nearshore directly below shore-based industrial or municipal outfalls, rather than in the main current of the river. The concentrations of contaminants found in tissues, therefore, reflects the concentrations in the tributaries and nearshore waters, rather than background levels in the Niagara River.

Of the 28 organochlorine contaminants looked for, 17 were detected in mussel tissues from one or more stations. Concentrations of PCBs (polychlorinated biphenyls), chlorinated benzenes and most of the organochlorine contaminants in mussel tissue were below the method detection level at all stations on the Canadian side of the Niagara River with the exception of trace levels of DDT metabolites which were found at most stations, and β-BHC (hexachlorocyclohexane) and γ-chlordane which were found at two and one station respectively on the tributaries (Table 2 and 3, Figure 2). On the U.S. side of the river, PCBs were detected in mussel tissues at all stations above Niagara Falls. (Table 2, Figures 2) and in most cases represent low level active sources. The highest levels of PCBs were found at the mouth of Gill Creek (935 ng/g) followed by the Occidental's sewer 003 site (322 ng/g). These two stations both located in Niagara Falls New York represent active sources of PCBs.

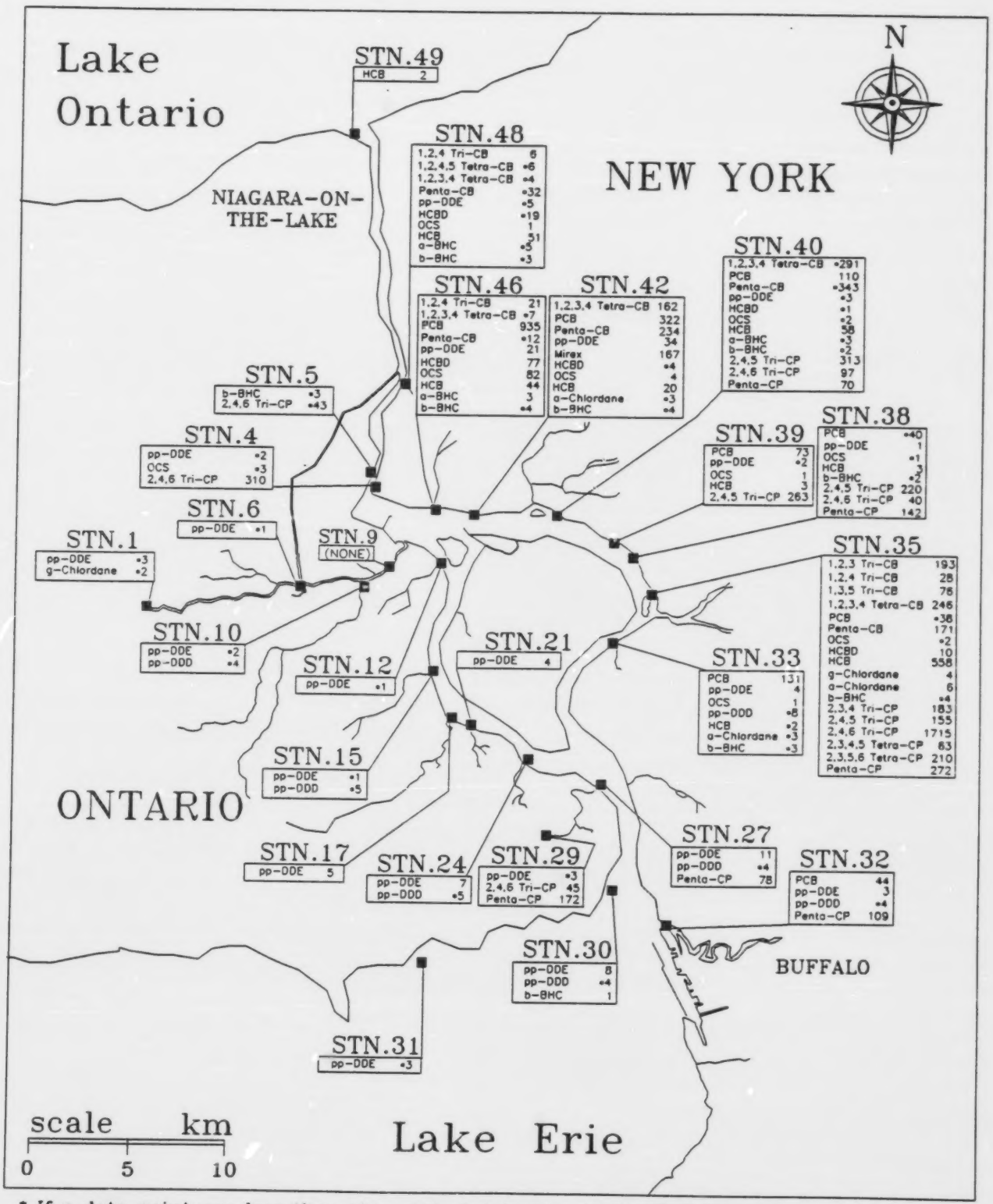
Organochlorine pesticide residues in mussel tissues on the U.S. side of the river were generally at low levels with the exception of mirex, HCB (hexachlorobenzene) and p,p'-DDE. The mean tissue concentration of mirex in mussels exposed at the Occidental sewer 003 outfall was 167 ng/g. At all other sites mirex levels were below the analytical

Table 2. Mean (three replicate samples) tissue concentrations (ng/g) of PCBs and organochlorine pesticides in mussels exposed in the Niagara River, 1987.

Location (Station Number)	Contaminants								
Canadian Sites	PCB	pp-DDE	pp-DDD	HCB	γ-Chlordane	α-Chlordane	α-BHC	β-BHC	Mirex
Welland R. at Airport (1)	-	* 3	-	-	2	-	-	-	-
Maid of the Mist Pool (5)	-	-	-	-	-	-	-	* 3	-
Welland R. at Power Canal (6)	-	* 1	-	-	-	-	-	-	-
Chippawa Creek (9)	-	-	-	-	-	-	-	-	-
Lyons Creek (10)	-	* 2	* 4	-	-	-	-	-	-
Ussher's Creek (12)	-	* 1	-	-	-	-	-	-	-
Boyers Creek (15)	-	* 1	* 5	-	-	-	-	-	-
Black Creek (17)	-	5	-	-	-	-	-	-	-
Baker Creek (21)	-	4	-	-	-	-	-	-	-
Miller Creek (24)	-	7	* 5	-	-	-	-	-	-
Frenchman's Creek (27)	-	11	* 4	-	-	-	-	-	-
Frenchman's Creek at Durez (29)	-	* 3	-	-	-	-	-	-	-
Fort Erie at Robertson St. (30)	-	8	* 4	-	-	-	-	1	-
Thunder Bay, Lake Erie (31)	-	* 3	-	-	-	-	-	-	-
American Sites									
Falls St. Tunnel (4)	-	* 2	-	-	-	-	-	-	-
Buffalo River (32)	44	3	* 4	-	-	-	-	-	-
Two Mile Creek (33)	131	* 3	* 8	* 2	-	* 3	-	* 3	-
Pettit Flume (35)	* 38	-	-	558	4	6	-	* 4	-
Gratwick - Riverside Park (38)	* 40	1	-	3	-	-	-	* 2	-
Wheatfield (39)	73	* 2	-	3	-	-	-	-	-
102nd Street (40)	110	* 3	-	58	-	-	* 3	* 2	-
Occidental's Sewer 003 (42)	322	34	-	20	-	* 3	-	4	167
Gill Creek (46)	935	21	-	44	-	-	3	* 4	-
Bloody Run Creek (48)	-	* 5	-	51	-	-	* 5	* 3	-
Niagara-on-the-Lake (49)	-	-	-	-	-	-	-	-	-
Method Detection Limit (ng/g)	20	1	5	1	2	2	1	1	5

NOTE: - :not-detected

* :If a data point was less than the method detection limit the mean was calculated using one-half the detection limit.



* If a data point was less than the method detection limit the mean was calculated using one-half the detection limit. Note:CB=Chlorobenzene,CP=Chlorophenol

Fig.2. CONTAMINANT CONCENTRATIONS (ng/g)(mean of 3 samples) DETECTED IN EXPOSED MUSSELS IN THE NIAGARA RIVER, 1987

detection limit of 5 ng/g. This indicates that the Occidental sewer is an active source of mirex. HCB levels found in samples at Occidental's Pettit Flume in North Tonawanda (558 ng/g) were significantly higher than at the remainder of the stations ($p<0.05$). Concentrations were also higher at stations downstream of Pettit Flume compared with upstream sites, possibly suggesting a downstream influence of the discharge. The DDT metabolite p,p'-DDE was found throughout the Niagara River at most stations sampled and when analyzed using Tukey's HSD test, the stations fell into three homogeneous, overlapping groups (Appendix Table 2). The group with the highest levels consisted of samples from Occidental's sewer 003 at 34 ng/g and those from Gill Creek at 21 ng/g. The second homogenous group consisted of Gill Creek, Frenchman's Creek (11 ng/g), Fort Erie (8 ng/g) and Miller Creek (7 ng/g). The remainder of the stations made up the third group. The presence of p,p'-DDE in mussels at almost every station suggests an overall loading to the river likely from past agricultural practices. Historically metabolites of DDT were found in spottail shiners and appeared at almost all sampling stations again in 1987 (Suns *et. al.*, 1991).

Chlorinated Benzenes/Industrial Chlorinated Compounds

Levels of octachlorostyrene (OCS) (82 ng/g) and hexachlorobutadiene (HCBD)(77 ng/g) (Table 3 and Figure 3) in mussels from Gill Creek were significantly higher than at the remainder of the stations ($p<0.05$), suggesting Gill Creek as an active source of these contaminants. Octachlorostyrene was found at trace levels at most of the stations on the U.S. side upstream of Gill Creek, showing low level inputs, but was not present at any Canadian stations. Hexachlorobutadiene was found in samples from a few stations upstream of Gill Creek and at Bloody Run Creek at trace levels, but was also absent from the Canadian sites.

Pentachlorobenzene was found in mussel tissues at the same locations that HCBD was found (Figures 2 and 3). The highest levels were observed in samples from 102nd Street (343 ng/g), followed by Occidental's sewer 003 (204 ng/g) and the Pettit Flume (171 ng/g). Lower concentrations were found downstream (eg. Gill Creek) and are possibly the result of these upstream source loadings.

Most of the other chlorinated benzene compounds were not detected in the mussel tissues; however, of those compounds observed (Table 3), only the U.S. stations between the Pettit Flume and Niagara Falls had detectable levels. Pettit Flume, Gill Creek, 102nd Street and Occidental's sewer 003 had the highest levels of those compounds detected. Elevated levels of compounds found in mussel tissue from the Pettit Flume were not detected downstream at the Gratwick-Riverside Park and Wheatfield stations.

Polycyclic Aromatic Hydrocarbons

Table 4 provides the mean tissue concentrations of polycyclic aromatic hydrocarbons (PAHs) in mussels exposed in the Niagara River. Statistically higher ($P<0.05$) concentrations of phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluorene and benzo(a)pyrene were often observed in mussels at Two-Mile Creek (Tonawanda), Pettit Flume and Occidental's sewer 003 on the U.S. side of the river. There

Table 3. Mean (3 replicate samples) tissue concentrations (ng/g) of chlorobenzenes/chlorinated industrial organics in mussels exposed in the Niagara River, 1987.

Location (station number)	Contaminants							
American Sites	1,2,3 Tri-	1,2,4 Tri-	1,3,5 Tri-	1,2,3,4 Tetra-	1,2,4,5 Tetra-	Penta-	HCBD	OCS
	Chlorobenzene					Chlorobenzene		
Falls St. Tunnel (4)	-	-	-	-	-	-	-	* 3
Two Mile Creek (33)	-	-	-	-	-	-	-	1
Pettit Flume (35)	193	28	76	246	-	171	10	* 2
Gratwick-Riverside Park (38)	-	-	-	-	-	-	-	* 1
Wheatfield (39)	-	-	-	-	-	-	-	1
102nd Street (40)	-	-	-	* 291	-	* 343	* 1	* 2
Occidental's Sewer 003 (42)	-	-	-	162	-	234	* 4	4
Gill Creek (46)	-	21	-	* 7	-	* 12	77	82
Bloody Run Creek (48)	-	6	-	* 4	* 6	* 32	* 19	1
Method Detection Limit	2	2	2	1	1	1	1	1

NOTE: - :not-detected
* :If a data point was less than the method detection limit the mean was calculated using one-half the detection limit.
HCBD:Hexachlorobutadiene
OCS:Octachlorostyrene

The remaining sampling sites (all Canadian with the exception of the Buffalo R.) did not have detectable concentrations of all parameters:

Welland R. at airport	Baker Creek
Maid-of-Mist Pool	Miller Creek
Welland R. at power canal	Frenchman's Creek
Chippawa Creek	Frenchman's Creek at Durez
Lyons Creek	Fort Erie at Robertson St.
Usshers Creek	Thunder Bay, Lake Erie
Boyers Creek	Buffalo River
Black Creek	Niagara-on-the-Lake

Fig.3. MEAN (3 samples) CONCENTRATION OF CHLOROBENZENE/INDUSTRIAL COMPOUNDS IN EXPOSED MUSSELS IN THE NIAGARA RIVER IN 1987.

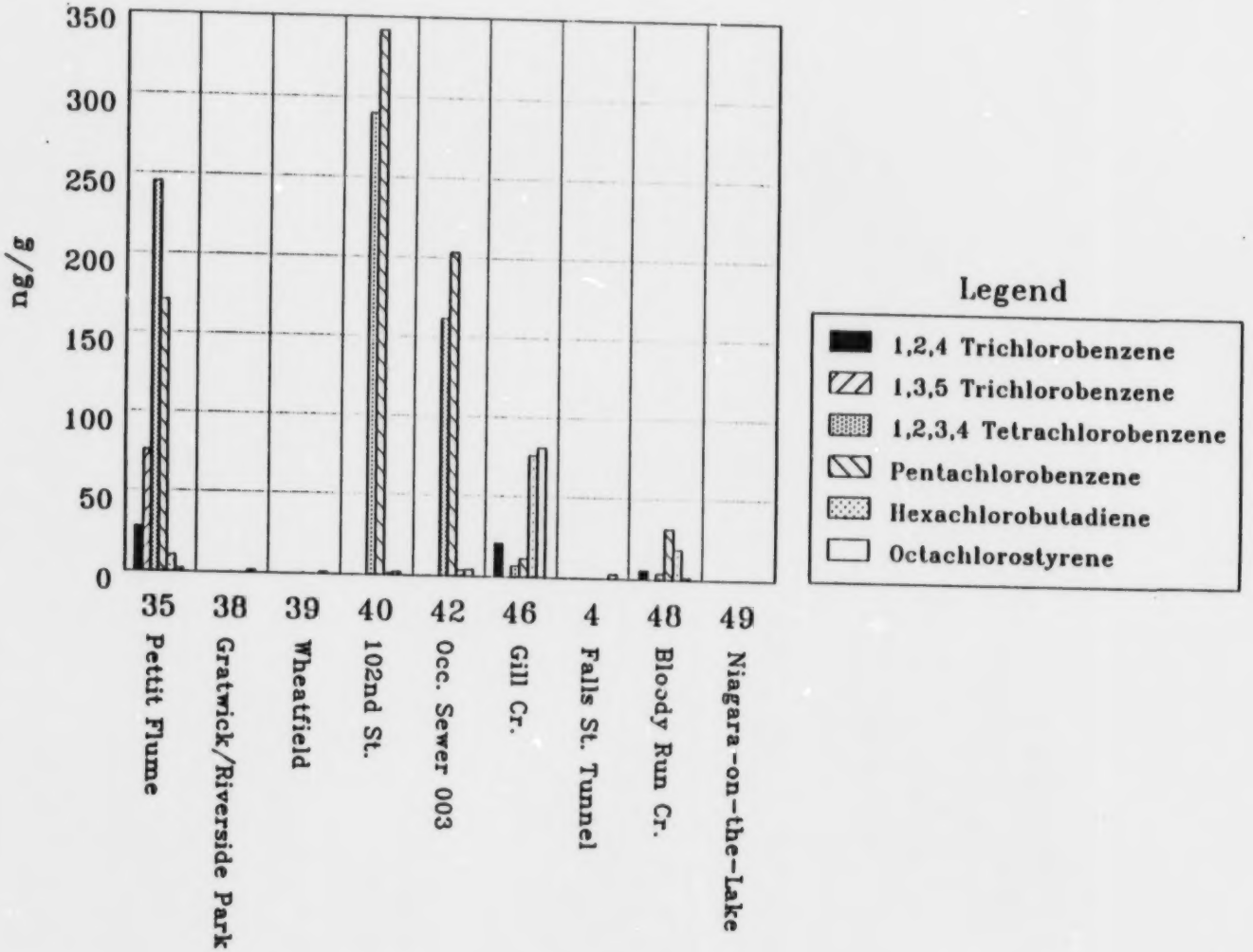


Table 4: Mean tissue concentrations(ng/g) (3 replicate samples) of Polycyclic Aromatic Hydrocarbons (PAHs) in mussels exposed in the Niagara River, 1987

Station Location	Naphthalene	Acenaphthylene | Acenaphthene	Fluorene	Phenanthrene	Fluoranthene	Pyrene	B(a)A	Chrysene	B(b)F	B(a)P	Dibenzo(ah)
Canadian Sites											
Welland R. at airport	-	-	-	-	-	22	*25	-	-	-	-
Welland R. at power canal	-	-	-	-	-	-	37	-	25	-	-
Chippawa Creek	-	-	-	34	71	130	99	*36	44	54	39[1]
Black Creek	-	-	-	-	-	-	-	-	-	-	47[1]
Miller Creek	-	*45	-	-	-	-	-	-	-	-	81
Frenchmans Creek	-	-	-	-	-	-	-	-	-	-	83[1]
Frenchmans Cr. at Durez	*25	*52	*21.5	-	-	-	-	-	-	-	-
Ft. Erie at Robertson St.	*30	*93	29.2	-	-	-	-	-	-	-	-
Thunder Bay, Lake Erie	37	153	32.2	-	-	-	-	-	-	-	-
American Sites											
Buffalo River	-	*42	-	-	-	46	138	-	62	60	-
Two mile Creek	-	-	-	48	263	339	308	38	224	297	-
Pettit Flume	-	-	-	*22	148	393	377	64	254	190	36
Gratwick-Riverside Park	-	-	-	-	-	*29	*32	-	37	*33	-
Wheatfield	-	-	-	-	-	*26	30	-	*32	40	-
102nd St.	-	-	-	-	-	*27	26	-	32	*24	-
Occidental's sewer 003	-	-	-	-	33	162	191	98	162	226	54
Bloody Run Creek	-	-	-	-	-	-	-	-	22[1]	-	-
Method Detection Limit	20	20	20	20	20	20	20	20	20	20	20	40

NOTE: - :not-detected
* :If a data point was less than the method detection limit the mean was calculated using one-half the detection limit.
[1] :one sample analysed [2]:mean is based on two samples

B(a)A: Benz(a)anthracene B(b)F: Benzo(b)fluorene B(a)P: Benz(a)Pyrene Dibenz(ah)A: Dibenzo(ah)anthracene

The remaining sites had non-detectable concentrations of all PAHs

Falls St. Tunnel	Boyers Creek	Lyons Creek	Usshers Creek
Maid-of-the-Mist Pool	Bakers Creek	Gill Creek	Niagara-on-the-Lake

appears to be some migration of these contaminants downstream. Mussels at the U.S.Table stations upstream of the falls all contain some PAHs, however, they were at lower concentrations than the three sites listed above. On the Canadian side of the river, PAHs were observed at the Chippawa Creek station, with low concentrations of two or three PAHs recorded on the Welland River and on the smaller tributaries. In general, the U.S. sites had higher concentrations of PAHs and more PAH compounds present than the Canadian sites.

A variety of PAHs were present in the sediment taken from both sides of the river (Table 5). The highest concentrations were in sediment on the U.S. side. Sediment concentrations of PAHs did not reflect the concentrations found in the mussels, nor were the same compounds present in mussels and sediment. In many cases compounds found in the sediment were not detected in mussels collected from the same station and vice versa suggesting differences in partitioning of PAHs between the sediment and mussels. The mussels will accumulate the PAHs from the water column while sediment PAH concentrations will be determined by a variety of sediment physical and chemical characteristics. For example, sediment from Wheatfield had some of the highest concentrations of PAHs, however, levels in biota were not elevated relative to other stations where sediment concentrations were lower.

Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans

Results of polychlorinated dioxin and furan analysis for mussels and sediments from 12 sites are presented in Table 6. Chlorinated dibenzo-p-dioxins (CDD) and chlorinated dibenzofurans (CDF) were detected in mussels from stations on the Canadian side of the Niagara River. Tetrachlorinated dibenzofuran (4CDF) was present at all 5 stations, and hexachlorinated dibenzofuran (6CDF) and heptachlorinated dibenzofuran (7CDF) and three dioxin congeners (hexachlorinated dibenzo-p-dioxin (6CDD), heptachlorinated dibenzo-p-dioxin (7CDD), and octachlorinated dibenzo-p-dioxin (8CDD)) were present at the Thunder Bay station (control) in Lake Erie (Figure 4). Two Canadian sites (Frenchman's Creek (mouth) and Frenchman's Creek at Canadian Oxy-Chemicals Ltd ,Durez Division), had sediment analyzed for dioxins and furans. The source of dioxins and furans present in the sediment and mussels at these sites (Table 6) has not been determined but may be due to the presence of the Canadian Oxy-Chemical facility which produces phenolic resins.

Chlorinated dioxins and furans were present at several of the U.S. stations. Of most interest is 2,3,7,8 TCDD which is the most toxic of the chlorinated dioxin compounds. It was detected in mussels (200 pg/g) only at the Pettit Flume (which receives wastewater from an Occidental Chemical facility) and in sediment from the Pettit Flume (9 ng/g), Wheatfield (0.03 ng/g) and 102nd Street (0.03 ng/g) (Table 6). Other dioxin and furan compounds were found in mussels and sediment at the three stations listed above, however, Pettit Flume consistently had the highest concentrations in both mussels and sediment and is likely an important source to the river (Figure 5 and 6).

Table 5: Polynuclear aromatic hydrocarbons (ug/g dry wt) in Niagara River Sediments, July 1987
Each value represents an analysis of one composite sediment sample.

	Welland River at airport	Thompsons Creek at Cranauld	Welland River at Power canal	Ushers Creek	Bowers Creek	Black Creek	Baker Creek	Miller Creek	Frenchmans Creek (Durez)	Frenchmans Creek	Buffalo River	Pettit Flume	Wheatfield	102nd St.
Contaminant (MDL ug/g)														
Dibenzo(a,h)anthracene (0.04)	-	-	0.14	0.07	0.06	-	0.07	-	0.13	0.04	0.13	1.1	1.4	0.05
Benzo(g,h,i)perylene (0.04)	-	-	0.15	0.10	0.05	0.04	0.10	0.05	0.16	0.04	0.20	2.1	2.6	0.05
Naphthalene (0.04)	-	-	-	-	-	-	-	-	-	-	-	0.37	0.07	-
Acenaphthylene (0.05)	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-
Acenaphthene (0.04)	-	-	-	-	-	-	-	-	-	-	0.04	0.57	0.16	-
Fluorene (0.04)	-	-	0.04	-	-	-	-	-	-	-	0.07	1.4	0.24	-
Phenanthrene (0.07)	-	-	0.24	0.22	-	-	-	-	0.11	-	0.65	7.5	3.4	-
Anthracene (0.01)	-	-	0.05	0.08	-	-	-	-	0.03	-	0.19	1.4	0.88	-
Flouranthrene (0.02)	-	-	0.45	0.42	0.07	-	0.21	0.13	0.36	-	0.92	8.6	6.4	0.04
Pyrene (0.06)	-	-	0.73	0.37	-	-	0.18	0.11	0.34	-	0.80	7.0	6.0	ND
Benzo(a)anthracene (0.02)	0.04	0.04	0.35	0.20	0.09	0.04	0.09	0.05	0.14	0.02	0.42	4.7	3.2	0.04
Chrysene (0.02)	-	-	0.48	0.20	-	-	0.15	0.08	0.19	-	0.39	3.7	3.3	0.04
Benzo(k)fluoranthene (0.02)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluorene (0.06)	-	-	0.30	0.21	-	-	0.22	0.12	0.14	-	0.47	3.5	4.7	-
Benzo(e)pyrene (0.04)	-	-	0.24	0.20	-	-	0.14	0.08	0.22	-	0.38	2.3	4.3	0.05
Indeno(1,2,3-cd)pyrene (0.04)	-	-	0.15	0.13	0.06	0.06	0.12	0.06	0.19	0.04	0.24	2.8	3.1	0.06

Table 6. Chlorinated dibenzo-p-dioxins (CDD) and chlorinated dibenzofurans (CDF) in mussels (pg/g) placed in the Niagara River and in sediment (ng/g) collected from the river, 1987.

Dioxin and furan concentrations in mussels (pg/g)

Location (station number)	Dioxins						Furans				
Canadian Sites	2,3,7,8-TCDD	4CDD	5CDD	6CDD	7CDD	8CDD	4CDF	5CDF	6CDF	7CDF	8CDF
Chippawa Creek (9)	-	-	-	-	5	7	22	-	-	-	-
Frenchman's Creek (27)	-	-	-	-	-	-	63	-	-	-	-
Frenchman's Creek at Durez (29)	-	-	-	-	-	-	14	-	-	-	-
Fort Erie at Robertson St. (30)	-	-	-	-	-	-	30	-	-	-	-
Thunder Bay Lake Erie (31)	-	-	-	130	190	190	20	-	110	88	-
American Sites											
Pettit Flume (35)	200	3400	3300	200	-	70	20000	55000	10000	3800	3300
Gratwick Riverside Park (38)	-	-	-	-	-	-	64	-	-	-	-
Wheatfield (39)	-	-	-	-	-	20	210	300	130	150	110
102nd Street (40)	-	-	-	-	100	300	1100	1200	350	46	36
Occidental Sewer 003 (42)	-	-	-	-	-	52	3400	290	-	98	120
Bloody Run Creek (48)	-	-	-	-	-	-	58	-	-	-	-
Niagara-on-the-Lake (49)	-	-	-	-	-	-	33	-	-	-	-

Dioxins and Furans in Sediment (ng/g)

Location (station number)	2,3,7,8-TCDD	4CDD	5CDD	6CDD	7CDD	8CDD	4CDF	5CDF	6CDF	7CDF	8CDF
Frenchman's Creek (27)	-	-	-	-	0.21	0.90	-	-	0.06	0.15	0.11
Frenchman's Creek at Durez (29)	-	-	-	-	-	-	-	-	0.01	0.44	0.44
Pettit Flume (35)	9	620	560	980	360**	400**	1700	2700	7400	3900**	13000**
Wheatfield (39)	0.03	0.17	0.24	0.22	0.20	0.48	0.37	0.57	2.1	5.3	7.3
102nd Street (40)	0.03	0.06	0.08	0.55	2.0	7.5	0.25	0.39	0.83	1.3	2.0

All data were corrected for recovery of internal standards, except where indicated with "**". NOTE: - :not-detected

FIG. 4 NIAGARA RIVER MONITORING THUNDER BAY–LAKE ERIE POLYCHLORINATED DIOXIN & FURAN DATA, 1987.

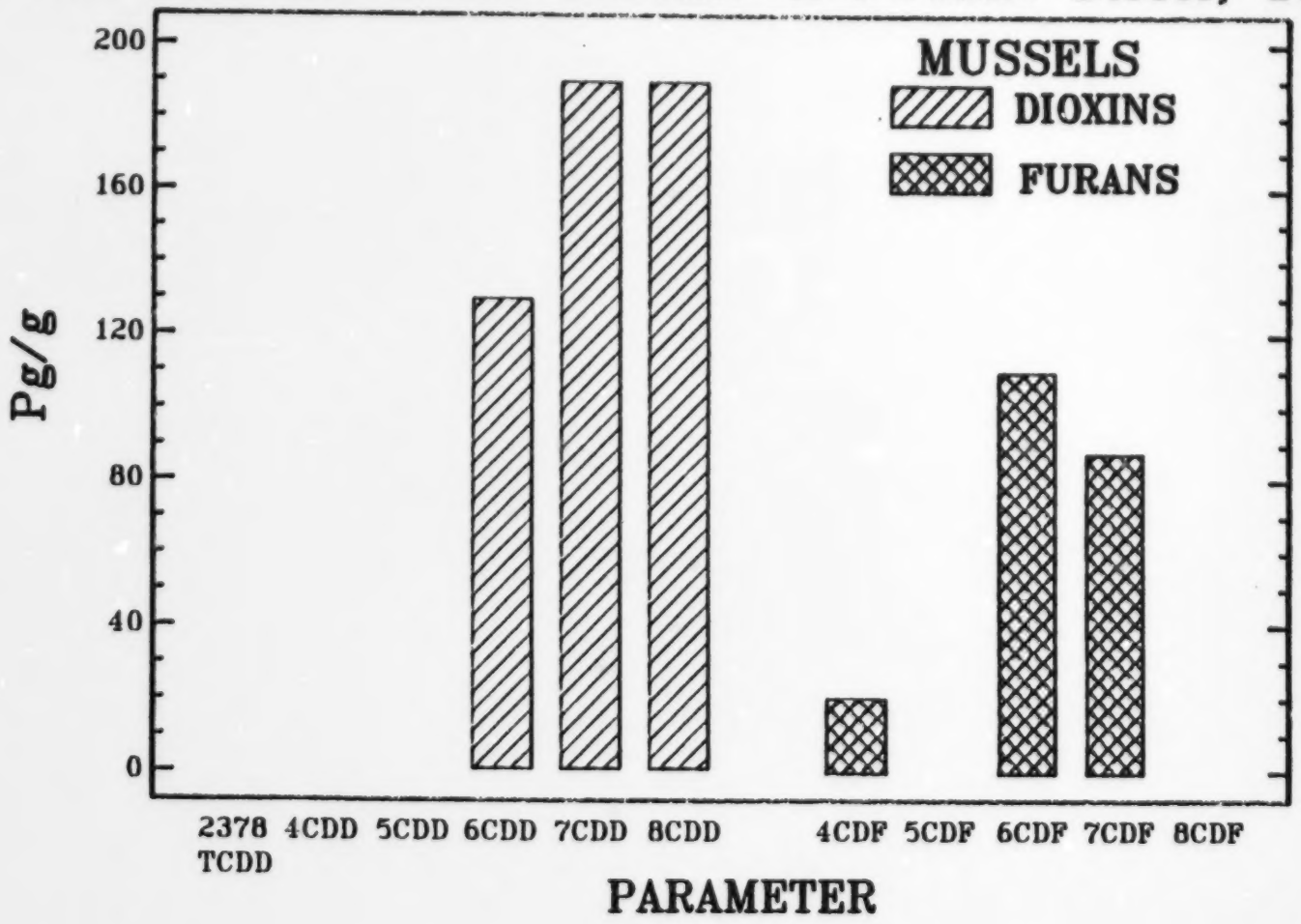


FIG. 5 NIAGARA RIVER MONITORING PETTIT FLUME POLYCHLORINATED DIOXIN & FURAN DATA, 1987.

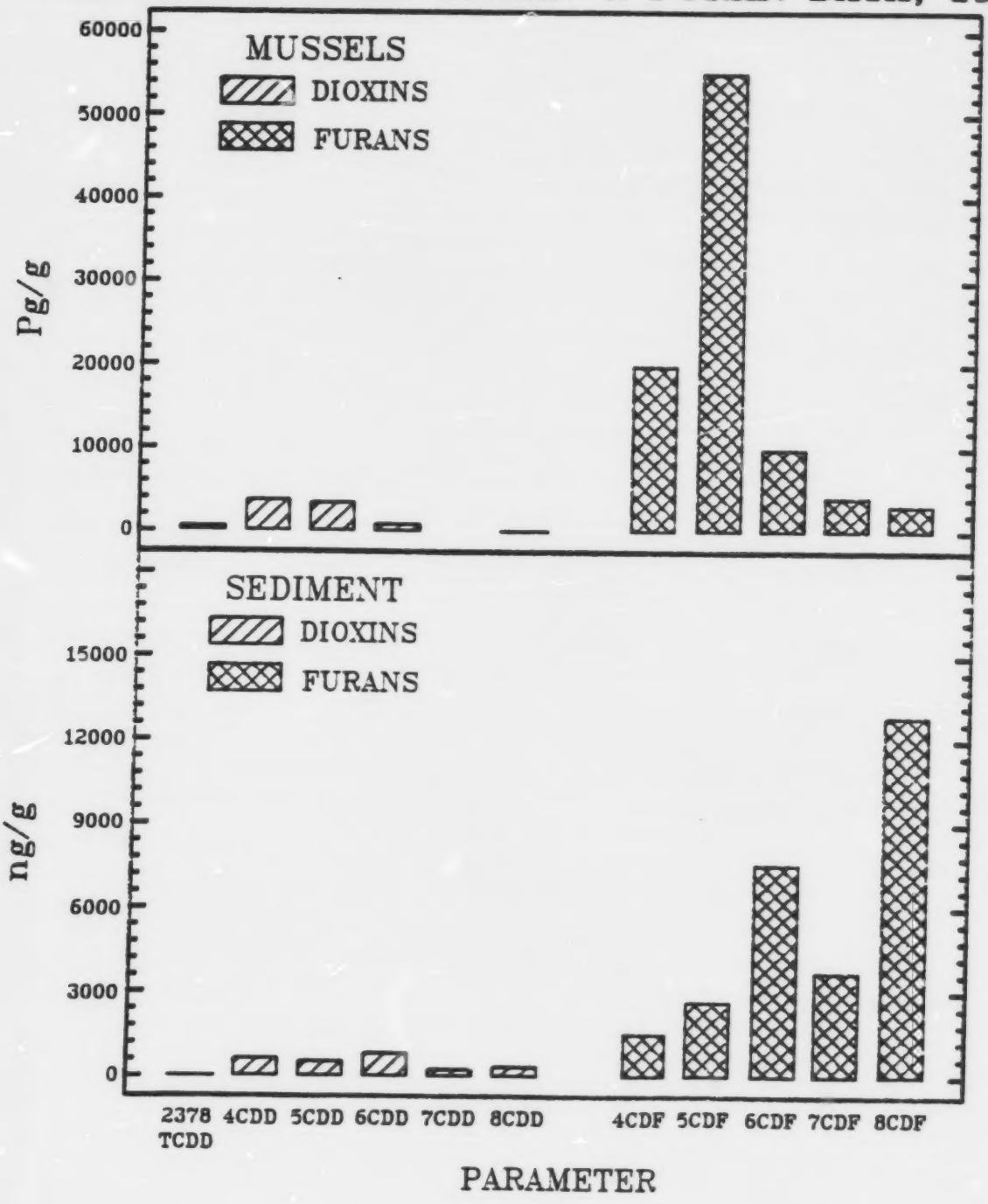
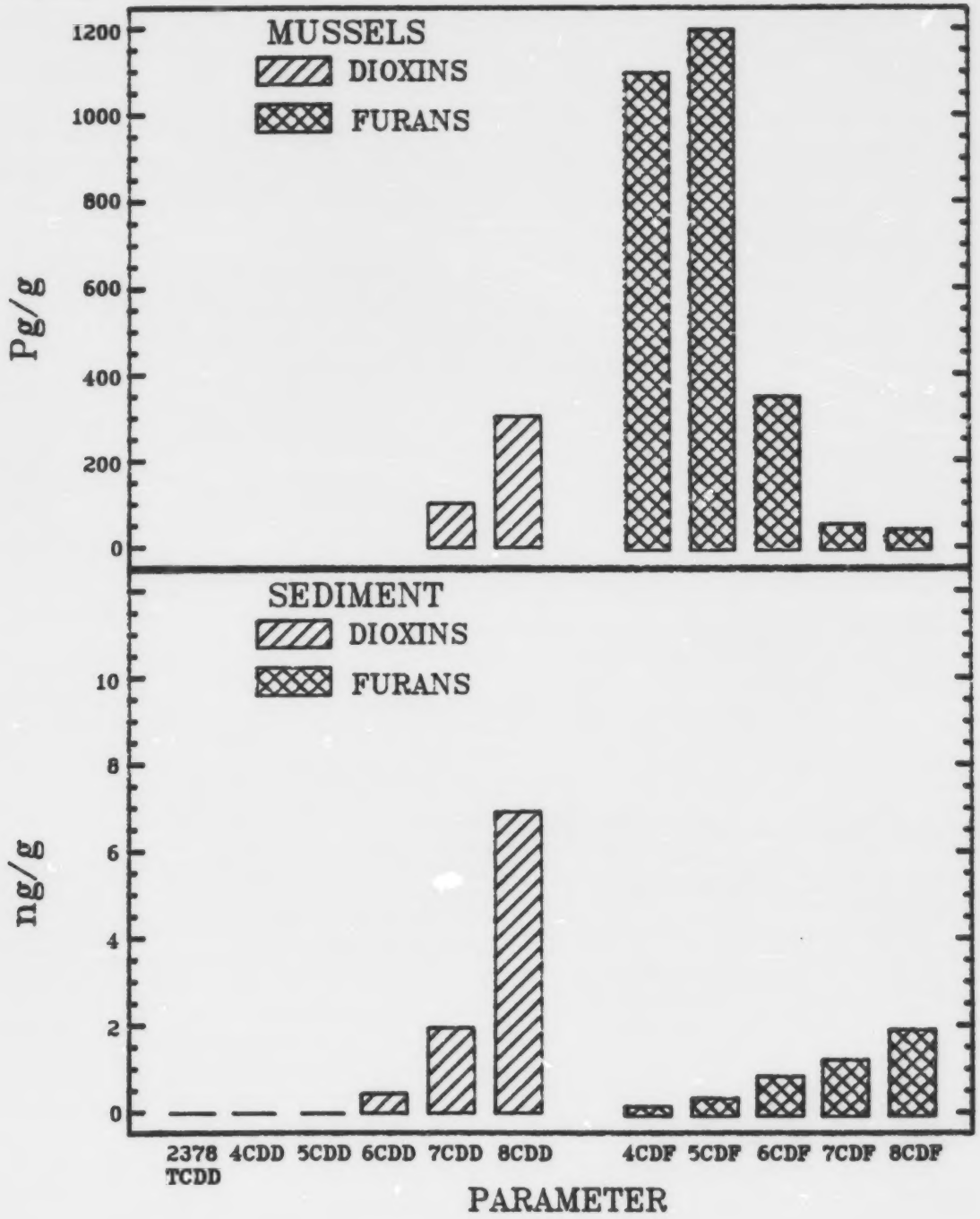


FIG 6 NIAGARA RIVER MONITORING 102nd STREET WASTE SITE POLYCHLORINATED DIOXIN & FURAN DATA, 1987.



In a previous study, mussels accumulated higher concentrations of the lower chlorinated dioxins and furans with particular emphasis on the tetra and penta congeners rather than the higher chlorinated compounds, even though higher concentrations of the higher chlorinated congeners were present in the water and sediment (Kauss, 1991 personal communication). This pattern of greater accumulation of the lower chlorinated congeners was also observed in mussels in this study, with the exception of Thunder Bay, Lake Erie, where higher concentrations of hexa, hepta and octa chlorinated dibenzo-p-dioxin were present. The sediment analyzed had, in most cases, higher concentrations of furans than dioxins, however, there were higher concentrations of the higher chlorinated furan congeners rather than the tetra and penta chlorinated furans.

Leeches

Chlorinated Phenolics

Of the twelve sites monitored for chlorinated phenols in leech tissue, most locations had detectable levels of several of these compounds (Figure 7 and Table 7). The highest levels were found in leeches placed on the U.S. side of the river; in particular at the Pettit Flume where levels of 2,4,6-trichlorophenol reached a maximum of 4,080 ng/g (mean of 1,715 ng/g). No statistical trends were observed, however, all the U.S. sites as well as Frenchman's Creek on the Canadian side are associated with specific chlorophenol sources. The Canadian Oxy-Chemicals Ltd. plant Durez Division in Fort Erie has been a source of phenolics in the past and the results of this study have led to a further investigation within the plant of the effluent concentrations of phenols discharged to Frenchman's Creek (Odom, 1991, Personal Communication).

Cladophora

PCBs and Organochlorine Pesticides

No detectable levels of the organochlorine pesticides aldrin, γ-chlordane, heptachlor, o,p'-DDT and p,p'-DDT or of the chlorinated phenols (pentachlorophenol, trichlorophenols (2,3,4, 2,4,5, and 2,4,6), tetrachlorophenols (2,3,4,5 and 2,3,5,6)) were found in Cladophora on either side of the Niagara River (Table 8).

For the remaining organochlorines, the highest mean values for any pesticide found were consistently on the American side of the river. The pesticides α-chlordane and p,p'-DDD were found in trace quantities at Love Canal only ("trace levels" are defined as values between the Lowest Reportable Value and the Reliable Measurable Value). The highest concentration of mirex (263 ng/g) was found at the Occidental sewer 003 (as seen with mussels), and was present in samples from the Occidental sewer 003 control site, Landfill North (on Gill Creek) and Love Canal, a site located near the site used to monitor mussels at 102nd Street. Many of the other pesticides were also found in Cladophora collected from the U.S. side of the river (Table 8).

Table 7. Mean (three replicate samples) tissue concentrations (ng/g) of chlorophenols in leeches exposed in the Niagara River, 1987.

Location (Station Number)	Contaminant					
	2,3,4 Tri-	2,4,5 Tri-	2,4,6 Tri-	2,3,4,5 Tetra-	2,3,5,6 Tetra-	Penta
Canadian Sites		Chlorophenol		Chlorophenol		Chlorophenol
Maid-of-Mist-Pool (5)	-	-	* 43	-	-	-
Frenchman's Creek (27)	-	-	-	-	-	* 78
Frenchman's Creek at Durez (29)	-	-	* 45	-	-	172
Fort Erie at Robertson St (30)	-	-	-	-	-	-
Thunder Bay, Lake Erie (31)	-	-	-	-	-	-
American Sites						
Falls St. Tunnel (4)	-	-	310	-	-	-
Buffalo River (32)	-	-	-	-	-	109
Pettit Flume (35)	* 183	* 155	1715	* 63	* 210	* 272
Gratwick-Riverside Park (38)	-	220	* 40	-	-	* 142
Wheatfield (39)	-	263	-	-	-	-
102nd Street (40)	-	313	97	-	-	70
Niagara-on-the-Lake (49)	-	-	-	-	-	-
Method Detection Limit	100	50	50	50	50	50

NOTE: - :not-detected
* :If a data point was less than the method detection limit the mean was calculated using one-half the detection limit.

Fig.7. MEAN (3 samples) CONCENTRATION OF CHLOROPHENOLS IN EXPOSED LEECHES IN THE NIAGARA RIVER IN 1987.

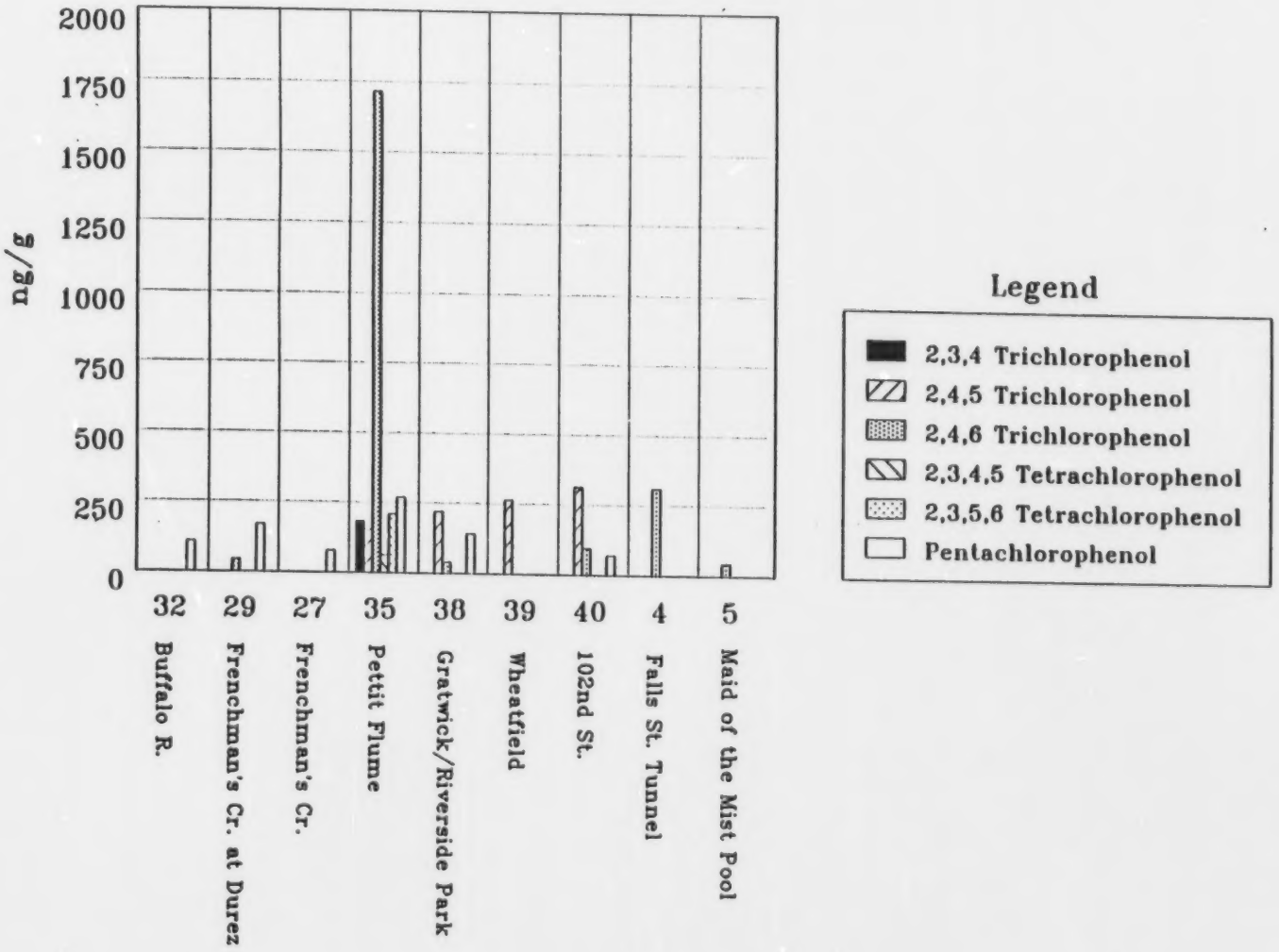


Table 8. Mean (3 subsamples) tissue concentrations (ng/g) of PCBs and organochlorine pesticides in Cladophora from the Niagara River, 1987.
LRV - Lowest Reportable Value; RMV - Reliable Measurable Value.

	CONTAMINANTS' (LRV/RMV)																
STATION	α-BHC 1/10	Y-BHC 1/10	β-BHC 1/10	DIEL 2/20	α-END 2/20	β-END 4/40	PPDe 1/10	α-CHLA 2/20	DMDT 5/50	ENDR 4/40	ENDS 4/40	HEPE 1/10	MIRX 5/50	OCHL 2/20	PCB 20/200	PP-DDD 5/50	HCB 1/10
Canadian Sites																	
Windmill Point	.	.	.	10	20	.	.	.	80	.	17	.	.	15	.	.	.
Fort Erie	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fort Erie - N.	.	.	.	.	.	.	10	.	.	.	.	.	.	.	.	.	.
Frenchman Ctrl.	.	.	.	.	.	.	36	.	.	.	.	.	.	.	.	.	.
Frenchman Mth.	.	.	.	.	.	.	<20	.	.	.	.	.	.	.	<58	.	.
Miller Cr. Ctrl.	.	.	.	.	.	.	8	.	.	.	.	.	.	.	<97	.	<2
Miller Cr. Mth.	.	.	.	.	.	.	12	.	.	.	.	.	.	.	<42	.	.
Baker Cr. Ctrl.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<85	.	<2
Baker Cr. Mth.	.	.	.	.	.	.	<4	.	.	.	.	.	.	.	<37	.	.
Black Cr. Ctrl.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<53	.	.
Black Cr. Mth.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<30	.	.
Boyers Cr. Ctrl.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Boyers Cr. Mth.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Usshers Cr. Ctrl.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Usshers Cr. Mth.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Usshers Cr. Inst.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pell Cr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	32	.	.
Lyons Cr.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fort George	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8 continues on next page

	CONTAMINANTS[1] (LRV/RMV)																
	α-BHC 1/10	γ-BHC 1/10	β-BHC 1/10	DIEL 2/20	α-END 2/20	β-END 4/40	PPDe 1/10	α-CHLA 2/20	DMDT 5/50	ENDR 4/40	ENDS 4/40	HEPE 1/10	MIRX 5/50	OCHL 2/20	PCB 20/200	PP-DDD 5/50	HCB 1/10
American Sites																	
Strawberry Is.	.	.	.	.	.	.	<3	.	.	.	.	.	.	.	<32	.	.
Black Rock Canal	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<85	.	<2
2-Mile Cr. Ctrl.	.	.	.	.	.	.	<10	.	.	.	.	.	.	.	<47	.	.
2-Mile Cr. Mth.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	115	.	.
Pettit Ctrl.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<40	.	<2
Pettit Mth.	.	.	.	.	.	.	<5	.	.	.	.	.	.	.	.	.	189
Tonawanda	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gratwick	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wheatfield	.	.	.	.	.	.	<3	.	.	.	.	.	.	.	87	.	3
Love Canal	<592	<45	<357	32	<23	27	32	<11	<80	<16	.	19	<30	<5	1293	<8	176
003 Sewer Ctrl.	.	.	.	38	28	<15	17	.	.	<35	.	17	<58	.	673	.	8
003 Sewer	<2	.	<2	18	24	<9	73	.	.	47	.	14	263	.	1337	.	354
Gill Cr. Ctrl.	3	.	6	8	<14	15	.	.	<22	.	20	<7	.	<7	.	.	5
Gill Cr. Mth.	<9	<2	<26	10	<8	<17	<34	.	<48	.	27	14	.	<8	2233	.	53
Landfill North	<2	.	.	15	.	<9	9	.	.	<17	.	12	<42	.	313	.	4
Bloody Run Mth.	<2	.	.	20	23	29	4	.	142	.	47	20	.	18	<47	.	37

NOTE: . :Results below LRV
< :The mean was calculated using at least one "trace level" value. Trace is defined as a value between the Lowest Reportable Value (LRV) and the Reliable Measurable Value (RMV).
Ctrl: Control
Mth: Mouth

[1] BHC;Hexachlorocyclohexane, DIEL;Dieldrin, α-END;α-Endosulfan, β-END;β-Endosulfan, α-CHLA;α-Chlordane, DMDT;Methoxychlor, ENDR;Endrin, ENDS;Endosulfan sulphate, HEPE;Heptachloroepoxide, MIRX;Mirex, OCHL;Oxychlordane, PCB;polychlorinated biphenyls, HCB;Hexachlorobenzene

On the Canadian side of the river, the control site in Lake Erie (Windmill Point) was the only site that had any detectable concentration of organochlorine pesticides (for example; methoxychlor, dieldrin, α-endosulphan, endosulphan sulphate, oxychlordane and hexachlorobenzene). Methoxychlor was the only pesticide listed above, that was detected above trace levels. As with mussels, trace levels of p,p'-DDE were widespread in Cladophora.

PCBs were detected in trace amounts in samples from several tributaries on the Canadian side of the river, however, the highest mean concentrations were found in samples collected from the U.S. side near the Love Canal (1,293 ng/g), and Occidental's sewer 003 (1,337 ng/g) sites and at the mouth of Gill Creek (2,233 ng/g). This is the same pattern as PCBs in mussels.

Chlorinated Benzenes/Industrial Chlorinated Compounds

On the Canadian side of the river Cladophora had detectable levels of chlorinated benzenes. These were elevated above the background Lake Erie concentrations at most sites. Exceptions were 1,2,3 trichlorobenzene and 1,2,4,5 tetrachlorobenzene which were only found in trace quantities and 26a Trichlorotoluene which was not found in reportable amounts. On the U.S. side, elevated concentrations were reported for all of the 13 detected chlorobenzene compounds (Table 9). The highest concentration of hexachlorobutadiene and octachlorostyrene (<325 ng/g and 173 ng/g respectively), were found in Cladophora taken from the U.S. side at the Occidental sewer 003, while Love Canal had the highest concentrations of pentachlorobenzene (1,587 ng/g) and several other compounds.

Temporal Trends

In the 1987 study of caged mussels, concentrations of some contaminants were much higher (in some cases orders of magnitude) than in previous years. Mirex in mussels placed at Occidental's sewer 003 was 17 ng/g in 1983 compared with 167 ng/g in 1987. Pentachlorobenzene and 1,2,3,4-tetrachlorobenzene in mussels from the Pettit Flume, Love Canal and Occidental's sewer 003 were also higher in 1987 compared with previous years. The same was true for hexachlorobenzene (HCB) at Pettit Flume and HCB and octachlorostyrene at Gill Creek. These results may suggest an increase in bioavailability of these contaminants at these sites, however, fluctuating tissue contaminant concentrations between years and within a year can occur because of variations in the physical habitat (i.e. river flow, fluctuating water levels, water temperature etc.) or biological factors (i.e. breeding cycles, sex of biomonitors, uptake efficiencies etc.) (Kauss and Angelow, 1988). The actual location of the biomonitors in the river can also affect tissue contaminant concentrations since a slight deviation from the original site may mean that the contaminant plume is diluted to a greater or lesser extent.

PCB and HCB levels in mussels at Niagara-on-the-Lake in 1987 were lower than in the 1980-1983 period. Although still high, PCB concentrations have also decreased in mussels exposed at Occidental's sewer 003, Gill Creek and the mouth of Bloody Run Creek. This

Table 9. Mean (three subsamples) tissue concentrations (ng/g) of chlorinated benzenes and industrial chlorinated compounds in Cladophora from the Niagara River, 1987.

LRV - Lowest Reportable Value; RMV- Reliable Measurable Value.

	CONTAMINANTS[1] (LRV/RMV)												
STATION	HCBD 1/10	HCE 1/10	OCS 1/10	QCB 1/10	T236 1/10	T245 1/10	T26a 1/10	X123 2/20	X1234 1/10	X1235 1/10	X124 2/20	X1245 1/10	X135 2/20
Canadian Sites													
Windmill Point	58	3	NA	<4	<3	.	.	<3	<3	<2	21	<4	<7
Fort Erie	.	7	14	18	20	19	.	.	41	9	33	5	<8
Fort Erie - N.	.	<3	<3	<8	<7	<2	.	.	<2	<3	<15	<2	.
Frenchman Ctrl.	.	12	12	17	26	10	.	4	6	14	49	<6	28
Fort George	<32	15	8	17	14	7	.	.	5	.	38	.	<4
American Sites													
Strawberry Is.	<5	8	<4	12	30	24	<7	<7	19	<7	41	5	23
Pettit Ctrl.	7	4	.	5	30	16	6	.	7	3	24	3	.
Pettit Mth.	<14	34	<4	143	28	21	11	117	36	44	130	20	28
Tonawanda	12	5	.	4	<14	<10	<3	.	<3	<2	18	.	5
Gratwick	<10	<4	.	<3	<7	<14	<3	.	<2	.	<11	.	<4
Love Canal	.	10	16	1587	72	78	27	69	138	<118	<18	<192	<21
003 Sewer Ctrl.	.	6	8	28	30	19	31	<10	7	<4	<11	<7	3
003 Sewer	<325	10	173	252	139	122	19	11	129	<18	<86	<17	18
Gill Cr. Ctrl.	3	.	NA	.	.	.	.	.	<2	.	<3	.	.
Gill Cr. Mth.	65	<3	NA	<6	<2	.	<2	<4	<5	<3	28	<6	<7
Landfill North	.	3	11	3	<10	9	7	.	5	.	.	.	5
Bloody Run Mth.	9	2	NA	28	18	14	.	.	16	6	10	7	4

NOTE: NA :Sample not analyzed
. :Results below LRV
< :The mean was calculated using at least one "trace level" value. Trace is defined as a value between the Lowest Reportable Value (LRV) and the Reliable Measurable Value (RMV).
Ctrl: Control
Mth: Mouth

[1] HCBD;Hexachlorobutadiene, HCE;Hexachloroethane, OCS;Octachlorostyrene, QCB;Pentachlorobenzene, T236, T245 and T26a; Trichlorotoluenes, X123, X124, X135, X1234, X1235, X1245; Tri and Tetra Chlorobenzenes.

may be an indication that overall river loadings to Lake Ontario have decreased, although changes in river PCB concentrations can also be affected by variations in river flow, storm events and rainfall. Additional long-term data are required to adequately determine any overall trend. As well, the high variability associated with contaminant concentrations in mussel tissue within a site and between sites makes trend analysis difficult. Levels of HCBD (at Occidental's sewer 003), BHC (at Gill Creek and Bloody Run Creek) and HCB and pentachlorobenzene (at Bloody Run Creek) were all similar between years. HCB increased in samples from 102nd Street and Gill Creek but decreased at the Occidental sewer 003 site.

Chlorinated dibenzo-p-dioxins and furans were found in all media (water, sediment, caged mussels,spottail shiners) at Pettit Flume in 1985, and 2,3,7,8 TCDD was found in sediments and mussels (3.6 ng/g and 20 pg/g respectively) (Kauss, 1991 personal communication). When compared with 1983, the 1987 levels of 2,3,7,8 TCDD in sediment and mussels were somewhat higher (9 ng/g and 200 pg/g respectively). These findings indicate that there is still an active source of chlorinated dioxin and furans at this site and that 2,3,7,8 TCDD is available for uptake by both introduced and resident (Cladophora, spottail shiners) biota.

From 1980 - 1987 PCBs in Cladophora on the Canadian side have been reported in trace amounts only, with no definite increasing or decreasing trend over time (Appendix Table 3). On the American side of the river, high concentrations have been observed at the majority of the sites. This suggests that the American side continues to provide the major sources of PCBs to the Niagara River. Although PCB levels remain relatively high on the U.S. side of the Niagara, the results for Cladophora appear to show a decrease at Gill Creek and Bloody Run Creek similar to PCB results for mussels. In addition, Suns *et. al.*, 1991, also found that total PCBs in spottail shiners have significantly ($p<0.05$) decreased over time at Niagara-on-the-Lake, however, residues in the remaining Niagara River collections did not.

Since there was only one previous year of data for many of the other organic compounds analyzed in Cladophora (and only at selected sites), no comments can be made on actual trends.

Species Comparison

Although modes of uptake are different and there are differences in actual tissue concentrations, a comparison of contaminant concentrations between mussels, spottail shiners and Cladophora can substantiate data that points to particular sites as sources of contaminants.

The data for mussels (Figure 2) and Cladophora (Table 8 and 9) show that the majority of contaminants detected were found on the U.S. side of the river. Most contaminants detected were found at the Pettit Flume, 102nd Street/Love Canal sites, Occidental's sewer

003, and the mouth of Gill Creek and Bloody Run Creek. The highest concentration of most contaminants found in biota were consistently from the Occidental sewer 003 and 102nd Street landfill sites with high concentrations of some contaminants at the mouth of Gill Creek and the Pettit Flume.

The highest concentrations of PCBs for both mussels and Cladophora were consistently found at Gill Creek, Occidental's sewer 003, 102nd Street and Two-Mile Creek (Figure 8). The importance of Gill Creek as a source of PCBs is emphasized by high concentrations of PCBs found in spottail shiners in 1985 and high concentrations in these fish from neighbouring sites (Suns *et. al.*, 1991). HCB concentrations were highest in both mussels and Cladophora at Occidental's sewer 003, Pettit Flume, 102nd Street and Bloody Run Creek (Figure 9). Further confirmation that the Occidental sewer 003 is a source of HCB was 1987 data that showed elevated concentrations in spottail shiners (Suns *et. al.*, 1991). The highest mirex concentrations in mussels and Cladophora were at Occidental sewer 003 while the highest concentration of 1,2,3,4-tetrachlorobenzene in biota was at Pettit Flume. The three highest concentrations in mussels and Cladophora of 1,2,3,4 tetrachlorobenzene and pentachlorobenzene were all found at 102nd Street, Occidental and Pettit Flume (Figure 10 and 11). Pettit Flume appears to be an important source of chlorobenzenes in general, since many of the chlorobenzenes analyzed were found in mussels at that site, while in most cases they were not accumulated by mussels at any of the other stations.

In contrast, high concentrations of octachlorostyrene were found in Cladophora at Occidental's sewer 003, however, concentrations were not elevated in mussels. Also interestingly, tri and tetrachlorobenzene compounds were found in Cladophora at almost all stations on the U.S. side while in most cases they were not detected in mussels. This leads to some questions concerning temporal variability in contaminant input and perhaps in modes of uptake and bioavailability that should be addressed in future studies. Mussels and Cladophora were not sampled at the same time. Variability in contaminant input over time may explain differences in tissue concentrations.

SUMMARY AND CONCLUSIONS

A comparison of contaminant concentrations in mussel tissue, leech tissue and Cladophora from the river in 1987 with those in Lake Erie permitted the identification of areas of input and bioavailability of organic compounds. The data for mussels, leeches and Cladophora show that the majority of contaminants detected were found on the U.S. side of the river at Pettit Flume in North Tonawanda, 102nd Street and Love Canal landfill sites, Occidental's Buffalo Avenue plant (sewer 003), the mouth of Gill Creek and Bloody Run Creek. The highest concentration of most contaminants in biota were usually found at sites located at the Occidental sewer 003 outfall and 102nd Street hazardous waste site.

Based on this study, in most cases the contaminants were released from sources (point and non-point) in the Niagara River rather than from upstream sources in Lake Erie.

A summary of the contaminants found is as follows:

-PCBs (polychlorinated biphenyls), chlorinated benzenes and most of the organochlorine pesticide concentrations in mussel tissues were below the level of detection at all stations on the Canadian side of the Niagara River and at the Lake Erie control site, with only a few exceptions.

- PCBs were detected in mussels at all U.S. stations above Niagara Falls, with mussels from Gill Creek and Occidental's sewer 003 site having the highest concentrations.

- Occidental's sewer 003 was the only site where mirex was detected in exposed mussels.

-The metabolites of DDT, p,p'-DDD and p,p'-DDE were present in mussels at most stations in trace amounts which likely represents the historical widespread use for agricultural practices.

- Mussels at the mouth of Gill Creek had significantly higher concentrations of octachlorostyrene and hexachlorobutadiene compared with those from other stations. Trace concentrations were detected in samples from most U.S. sites but were not found in mussels at the Lake Erie control site or in mussels exposed on the Canadian side of the river. This suggests the Niagara Falls, New York area as a source of these contaminants.

- Mussels exposed at the Pettit Flume in North Tonawanda had significantly higher concentrations of hexachlorobenzene (HCB) compared with all other sites. Pettit Flume is likely an important source of chlorinated benzenes since many of the compounds were detected in mussels only at this station.

- Mussels exposed at Two Mile Creek (Tonawanda), Pettit Flume and Occidental's sewer 003 (Niagara Falls) had the highest concentrations of PAHs. Based on concentrations of PAHs in downstream sites, there is some evidence to suggest migration of these compounds.

- 2,3,7,8 TCDD was present in mussels only at the Pettit Flume (200 pg/g) and in sediments at Pettit Flume, Wheatfield and 102nd Street sites. Pettit Flume consistently had the highest concentrations of chlorinated dioxins and furans in both mussels and sediment and is likely an important source to the river.

- The highest mean concentration of chlorinated phenols (CP) in leeches were detected at Pettit Flume. All of the U.S. sites are indicated as active sources as well as Frenchman's Creek (Canadian Side).

- Locations of elevated contaminant levels in mussels agreed with information on known or suspected sources and correlated with the spatial differences observed in residue levels of indigenous biota (Cladophora & spottail shiners) from the river.

-In Cladophora the highest mean concentrations of PCBs, HCB, mirex, 1,2,3 trichlorobenzene, 1,2,3,4 tetrachlorobenzene and pentachlorobenzene were found at the same stations where high concentrations were found in mussels. Similar results for some contaminants were seen in spottail shiners.

Recommendations for future study:

- Investigate and eliminate sources of persistent contaminants to the Niagara River.

- The length of time for mussels to reach equilibrium for specific contaminants is still not known, accordingly, further research should continue. This is not required to meet the objectives of this study (i.e. presence/absence of the contaminant), however, if we want to assess the variability associated with the specific contaminant concentrations of the effluent both temporally and spatially, then we have to know when the biomonitor has reached equilibrium. It is known that the concentration of contaminants discharged to the Niagara River at specific sources is not consistent, accordingly, we have no way of determining if the concentrations found in exposed mussels reflects the concentration discharged to the river.

- A regular biomonitoring program should be maintained every 2 years to allow significant trends to be detected.

- Future studies should increase the range of sampling stations to represent open water conditions rather than only sampling at the shoreline to augment the Niagara River Toxic Management Plan monitoring program.

Although many of these contaminants can not be detected in the water column, their presence is confirmed by their detection in mussels, Cladophora, leeches and spottail shiners. High concentrations at specific locations in all the biomonitors confirm these sites as sources and demonstrate the importance and benefits of extending aquatic contaminant studies further than only testing water quality.

FIG. 8 NIAGARA RIVER BIOMONITORING POLYCHLORINATED BIPHENYL DATA, 1987.

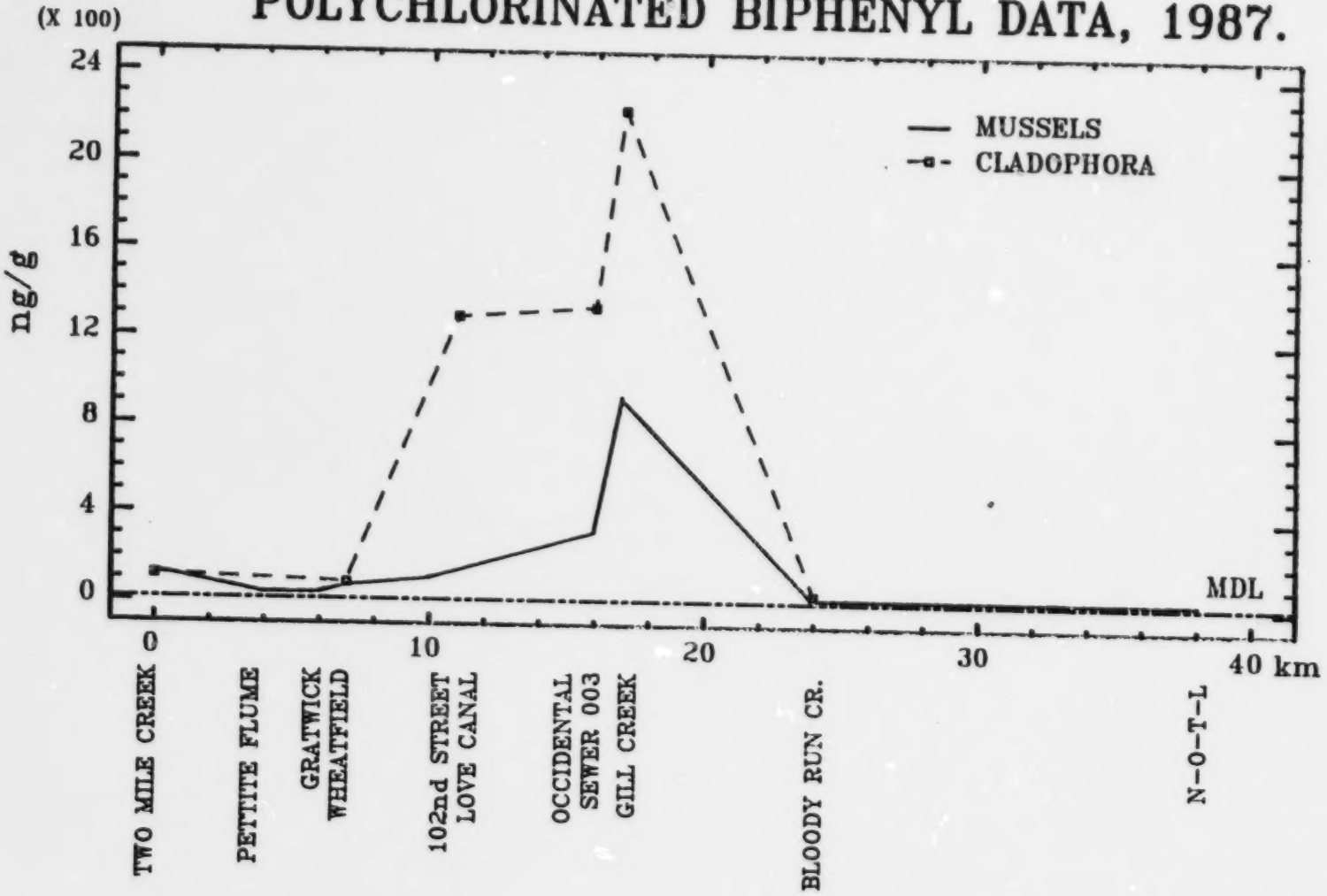


FIG. 9

NIAGARA RIVER BIOMONITORING HEXACHLOROBENZENE DATA, 1987.

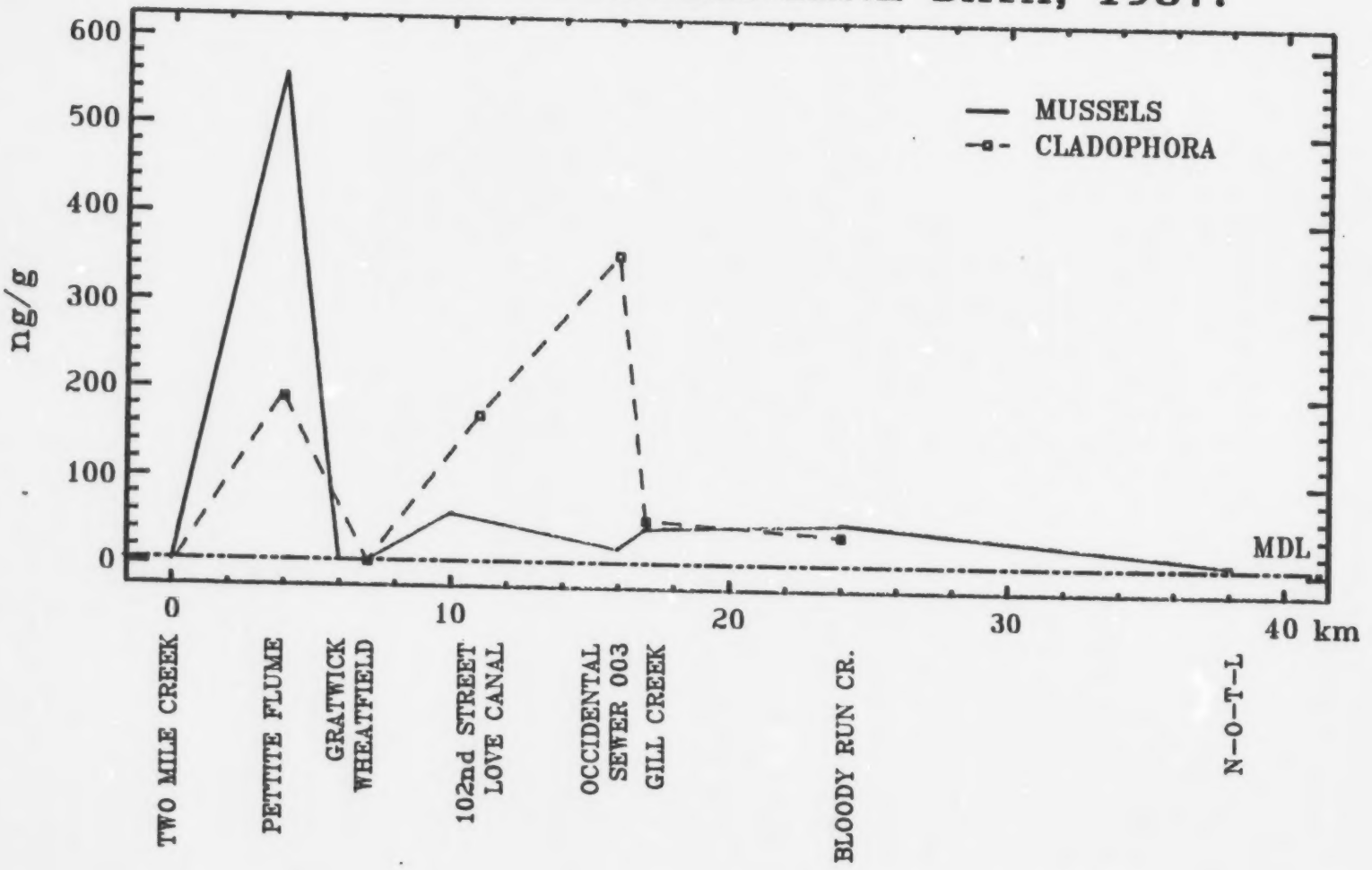


FIG. 10 NIAGARA RIVER BIOMONITORING 1,2,3,4 TETRACHLOROBENZENE DATA, 1987.

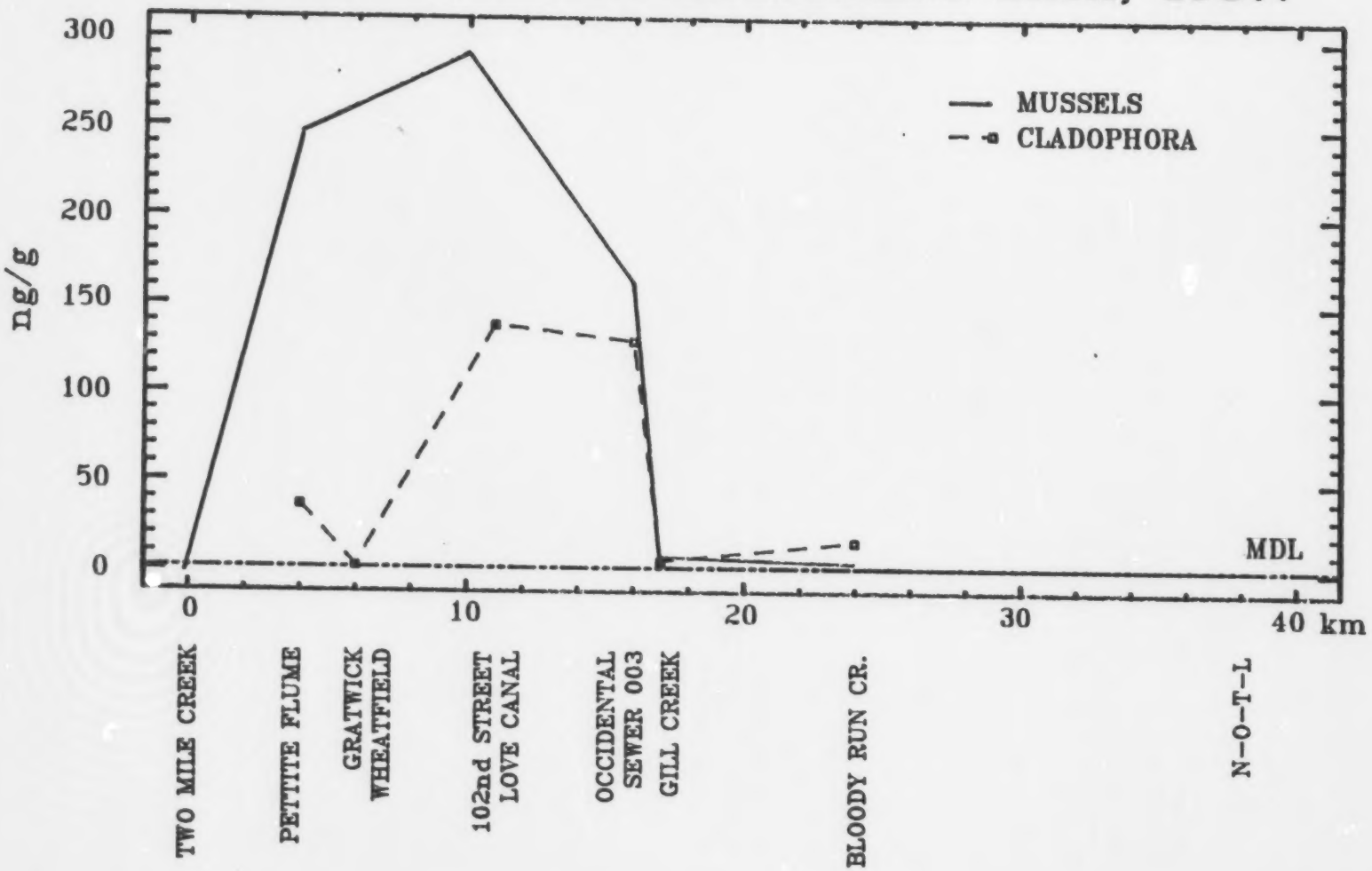
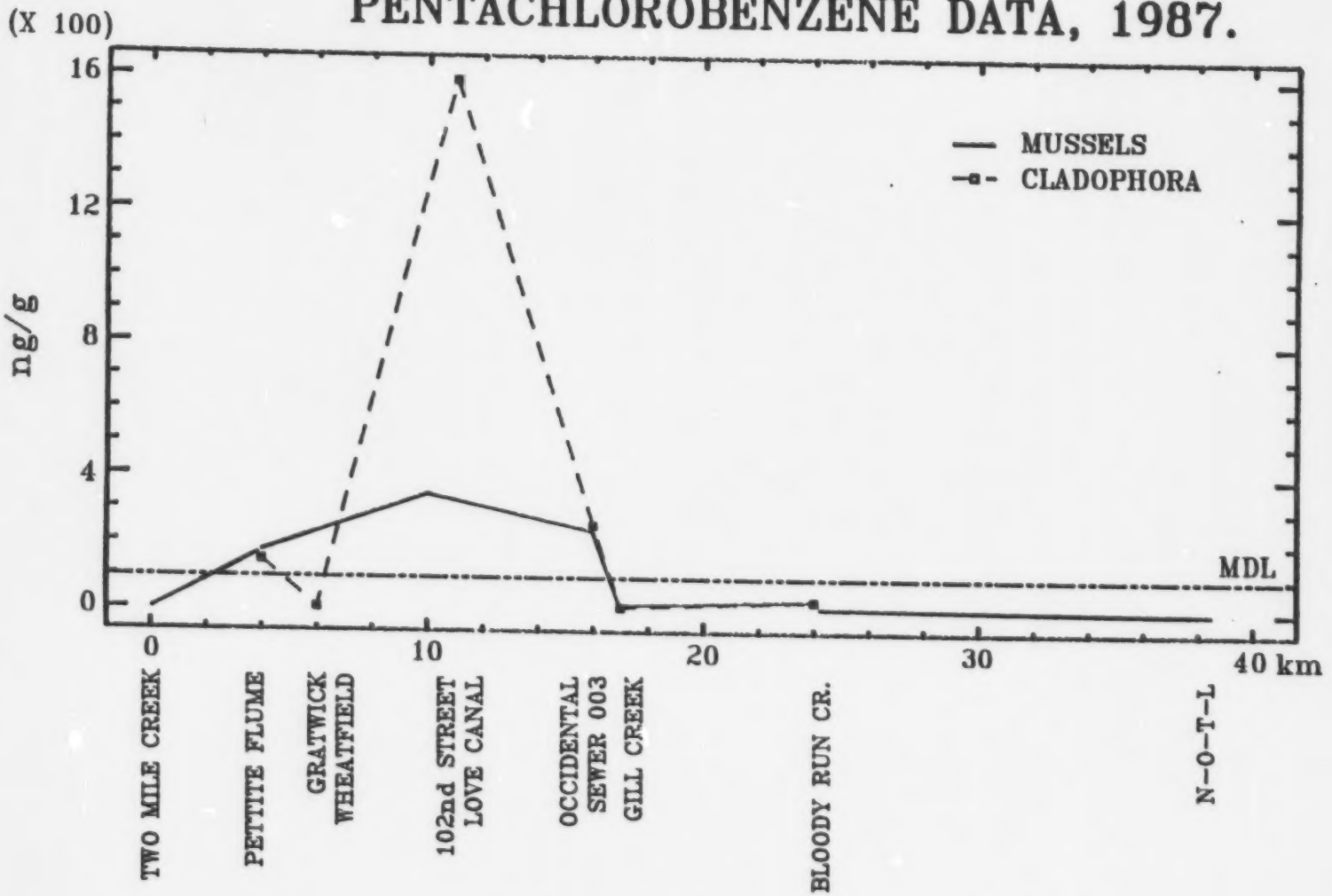


FIG. 11

NIAGARA RIVER BIOMONITORING PENTACHLOROBENZENE DATA, 1987.



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APPENDIX

Appendix Table 1. Cladophora test group analysis completed for each site on the Niagara River, 1987.

STATION	TEST GROUP		
Canadian Sites	OC	CB	CP
Windmill Point	x	x	x
Fort Erie	x	x	x
Fort Erie - N	x	x	x
Frenchman Cr. Control	x	x	x
Frenchman Cr. Mouth	x	-	x
Miller Cr. Control	x	-	-
Miller Cr. Mouth	x	-	-
Baker Cr. Control	x	-	-
Baker Cr. Mouth	x	-	-
Black Cr. Control	x	-	-
Black Cr. Mouth	x	-	-
Boyers Cr. Control	x	-	-
Boyers Cr. Mouth	x	-	-
Usshers Cr. Control	x	-	-
Usshers Cr. Mouth	x	-	-
Usshers Cr. Inst.	x	-	-
Pell Cr.	x	-	-
Lyons Cr.	x	-	-
Fort George	x	x	x
TOTAL	19	5	6
American Sites			
Strawberry Is.	x	x	x
Black Rock Canal	x	-	x
2-Mile Cr. Control	x	-	-
2-Mile Cr. Mouth	x	-	-
Pettit Flume Control	x	x	x
Pettit Flume Mouth	x	x	x
Tonawanda	x	x	x
Gratwick	x	x	x
Wheatfield	x	-	x
Love Canal	x	x	x
003 Sewer Control	x	x	-
003 Sewer	x	x	-
Landfill N.	x	x	x
Gill Cr. Control	x	x	-
Gill Cr. Mouth	x	x	-
Bloody Run Cr. Mouth	x	x	-
TOTAL	16	12	9

NOTE: OC - PCB/Organochlorine Pesticides
CB - Chlorinated Benzenes
CP - Chlorinated Phenols

x - analysis completed
\- no analysis

Appendix Table 2. Results of ANOVA and Tukey's HSD Test showing homogeneous,overlapping groups for the contaminant p,p'-DDE in mussels. (P<0.05)

Station	Mean Concentration (ng/g)	Homogeneous Groups			
5	.5(ND)	1			
9	.5(ND)	1			
35	.5(ND)	1			
49	.5(ND)	1			
6	1.0	1			
12	1.0	1			
38	1.0	1			
15	1.3	1			
4	1.7	1			
39	2.1	1			
10	2.3	1			
31	2.7	1			
40	2.7	1			
1	3.0	1			
29	3.2	1			
32	3.3	1			
33	3.5	1			
21	4.3	1			
17	5.0	1			
48	5.0	1			
24	7.0	1	2		
30	7.6	1	2		
27	10.7	1	2		
46	21.3		2	3	
42	34.0			3	4

Appendix Table 3. Mean PCB concentrations in *Cladophora* from the Niagara River, 1981-1987.

STATION	YEAR	PCB (ng/g)	STD DEV	N
Canadian Sites				
Fort Erie	83	< 22	3	3
	84	133	88	3
	85	< 20	0	3
	87	< 20	0	3
Frenchman Ctrl	85	< 20	0	3
	87	< 58	34	3
Frenchman Mth	81	62	8	3
	82	42	8	6
	84	78	10	3
	85	< 20	0	3
	87	< 97	93	3
Usshers Cr. Mth	82	63	42	3
	87	< 20	0	3
Fort George	81	52	22	3
	82	58	15	3
	83	57	16	3
	84	88	8	3
	85	< 20	0	3
	86	< 52	27	6
	87	< 20	0	3
American Sites				
Love Canal	81	358	101	3
	82	375	23	3
	83	152	21	3
	84	280	66	3
	85	347	222	9
	87	1293	508	3
003 Sewer Mth	83	125	23	3
	87	1337	597	3
Gill Cr. Ctrl	83	143	11	3
	87	< 20	0	3
Gill Cr. Mth	82	16333	1845	3
	83	4127	842	6
	84	4988	315	3
	85	3378	1573	22
	87	2233	115	3

Appendix Table 3 continues on next page

Appendix Table 3 cont.

Bloody Run Mth	82	1810	634	3
	83	737	129	3
	84	< 20	0	3
	85	348	203	7
	87	< 47	46	3
Control				
Windmill Point	81	53	10	3
	82	20	0	3
	83	< 37	21	3
	84	68	25	3
	85	< 20	0	3
	86	< 20	0	3
	87	< 20	0	3

< :The mean was calculated using at least one "trace level" value. Trace is defined as a value between the Lowest Reportable Value (LRV) and the Reliable Measurable Value (RMV).

Ctrl: Control
Mth: Mouth

APPENDIX TABLE 4

<T - This low measurement is tentative. For information only.

NSS - No suitable sample

P40 - Resembled mixture of Aroclor 1254 and 1260

Appendix Table 4.

NIAGARA RIVER BIOMONITORING STUDY, 1987

Chlorobenzenes, Organochlorine Pesticides/Industrial Contaminants and PCBs in Mussels
(ng/g Wet Weight)

SAMPLING LOCATION	REP	1,2,3,5-Cl4benzene	2,6,a-Cl3toluene	Hexachloro-ethane	1,3,5-Cl3benzene	1,2,4-Cl3benzene	Hexachloro-butadiene	1,2,3-Cl3benzene	2,4,5-Cl3toluene	2,3,6-Cl3toluene	1,2,4,5-Cl4benzene	1,2,3,4-Cl4benzene	penta-Clbenzene
1A WELLAND R. AT AIRPORT	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
1B WELLAND R. AT AIRPORT	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
1C WELLAND R. AT AIRPORT	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
4A FALLS ST. TUNNEL	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
4B FALLS ST. TUNNEL	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
4C FALLS ST. TUNNEL	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
5A MAID OF THE MIST POOL	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
5B MAID OF THE MIST POOL	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
5C MAID OF THE MIST POOL	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
6A WELLAND R. AT POWER CANAL	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
6B WELLAND R. AT POWER CANAL	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
6C WELLAND R. AT POWER CANAL	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
9A CHIPPAWA CR. BELOW BLOB	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
9B CHIPPAWA CR. BELOW BLOB	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
9C CHIPPAWA CR. BELOW BLOB	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
10A LYONS CR.	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
10B LYONS CR.	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
10C LYONS CR.	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
12A USSHERS CR.	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
12B USSHERS CR.	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
12C USSHERS CR.	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
15A BOYER'S CR.	A	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
15B BOYER'S CR.	B	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00
15C BOYER'S CR.	C	NSS	NSS	<T 1.00	<T 2.00	<T 2.00	<T 1.00	<T 2.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00

17A BLACK CR.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
17B BLACK CR.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
17C BLACK CR.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
21A BAKER CR.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
21B BAKER CR.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
21C BAKER CR.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
24A MILLER CR.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
24B MILLER CR.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
24C MILLER CR.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
27A FRENCHMAN'S CR.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
27B FRENCHMAN'S CR.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
27C FRENCHMAN'S CR.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
29A FRENCHMAN'S CR. AT DUREZ	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
29B FRENCHMAN'S CR. AT DUREZ	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
29C FRENCHMAN'S CR. AT DUREZ	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
30A FORT ERIE AT ROBERTSON ST.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
30B FORT ERIE AT ROBERTSON ST.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
30C FORT ERIE AT ROBERTSON ST.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
31A THUNDER BAY, L. ERIE	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
31B THUNDER BAY, L. ERIE	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
31C THUNDER BAY, L. ERIE	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
32A BUFFALO R.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
32B BUFFALO R.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
32C BUFFALO R.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
33A TWO MILE CR.	A	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
33B TWO MILE CR.	B	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
33C TWO MILE CR.	C	NSS	NSS	<1.00	<2.00	<2.00	<1.00	<2.00	<1.00	<1.00	<1.00	<1.00	<1.00
35A PETTIT FLUME	A	NSS	NSS	<1.00	98.00	26.00	9.00	131.00	<1.00	<1.00	<1.00	198.00	<1.00
35B PETTIT FLUME	B	NSS	NSS	<1.00	77.00	35.00	15.00	275.00	<1.00	<1.00	<1.00	314.00	513.00
35C PETTIT FLUME	C	NSS	NSS	<1.00	54.00	23.00	7.00	172.00	<1.00	<1.00	<1.00	225.00	<1.00

38A GRATWICK-RIVERSIDE PARK	A	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
38B GRATWICK-RIVERSIDE PARK	B	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
38C GRATWICK-RIVERSIDE PARK	C	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
39A WHEATFIELD	A	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
39B WHEATFIELD	B	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
39C WHEATFIELD	C	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
40A 102ND ST.	A	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	444.00	499.00
40B 102ND ST.	B	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	428.00	485.00
40C 102ND ST.	C	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	2.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	44.00
42A OCCIDENTAL SEWER 003	A	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	455.00	571.00
42B OCCIDENTAL SEWER 003	B	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	5.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	10.00	16.00
42C OCCIDENTAL SEWER 003	C	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	5.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	21.00	24.00
46A GILL CR.	A	NSS	NSS	(T 1.00	(T 2.00	8.00	8.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	19.00	38.00
46B GILL CR.	B	NSS	NSS	(T 1.00	(T 2.00	37.00	150.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 4.00
46C GILL CR.	C	NSS	NSS	(T 1.00	(T 2.00	18.00	72.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
48A BLOODY RUN CR.	A	NSS	NSS	(T 1.00	(T 2.00	15.00	51.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
48B BLOODY RUN CR.	B	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 2.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	32.00
48C BLOODY RUN CR.	C	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	4.00	(T 2.00	(T 1.00	(T 1.00	18.00	11.00	63.00
49A NIAGARA-ON-THE-LAKE	A	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
49B NIAGARA-ON-THE-LAKE	B	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00
49C NIAGARA-ON-THE-LAKE	C	NSS	NSS	(T 1.00	(T 2.00	(T 2.00	(T 1.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00

(T - THIS LOW MEASUREMENT IS TENTATIVE. FOR INFO ONLY NSS - NO SUITABLE SAMPLE P&O - RESEMBLED MIXTURE OF AROCLOR 1254 AND 1260

SAMPLING LOCATION	PCB Total	Hexachloro-benzene	Hepta-chlor	Aldrin	PP-DDE	Mirex	A-BHC	B-BHC	G-BHC
1A WELLAND R. AT AIRPORT	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
1B WELLAND R. AT AIRPORT	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
1C WELLAND R. AT AIRPORT	<T 20.00	<T 1.00	<T 1.00	<T 1.00	8.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
4A FALLS ST. TUNNEL	<T 20.00	4.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
4B FALLS ST. TUNNEL	<T 20.00	3.00	<T 1.00	<T 1.00	4.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
4C FALLS ST. TUNNEL	<T 20.00	5.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
5A MAID OF THE MIST POOL	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	9.00	<T 1.00
5B MAID OF THE MIST POOL	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
5C MAID OF THE MIST POOL	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
6A WELLAND R. AT POWER CANAL	<T 20.00	<T 1.00	<T 1.00	<T 1.00	2.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
6B WELLAND R. AT POWER CANAL	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
6C WELLAND R. AT POWER CANAL	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
9A CHIPPAWA CR. BELOW BLOB	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
9B CHIPPAWA CR. BELOW BLOB	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
9C CHIPPAWA CR. BELOW BLOB	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
10A LYONS CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
10B LYONS CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
10C LYONS CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	6.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
12A USSHERS CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
12B USSHERS CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	2.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
12C USSHERS CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
15A BOYER'S CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
15B BOYER'S CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	3.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
15C BOYER'S CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	<T 1.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
17A BLACK CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	10.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
17B BLACK CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	3.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
17C BLACK CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	2.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
21A BAKER CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	6.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
21B BAKER CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	4.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
21C BAKER CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	3.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
24A MILLER CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	4.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
24B MILLER CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	2.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00
24C MILLER CR.	<T 20.00	<T 1.00	<T 1.00	<T 1.00	15.00	<T 5.00	<T 1.00	<T 1.00	<T 1.00

27A FRENCHMAN'S CR.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	10.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
27B FRENCHMAN'S CR.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	11.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
27C FRENCHMAN'S CR.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	11.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
29A FRENCHMAN'S CR. AT DUREZ	(T 20.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
29B FRENCHMAN'S CR. AT DUREZ	(T 20.00	(T 1.00	(T 1.00	(T 1.00	5.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
29C FRENCHMAN'S CR. AT DUREZ	(T 20.00	(T 1.00	(T 1.00	(T 1.00	4.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
30A FORT ERIE AT ROBERTSON ST.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	11.00	(T 5.00	(T 1.00	3.00	(T 1.00
30B FORT ERIE AT ROBERTSON ST.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	6.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
30C FORT ERIE AT ROBERTSON ST.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	6.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
31A THUNDER BAY, L. ERIE	(T 20.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
31B THUNDER BAY, L. ERIE	(T 20.00	(T 1.00	(T 1.00	(T 1.00	7.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
31C THUNDER BAY, L. ERIE	(T 20.00	(T 1.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
32A BUFFALO R.	P40 81.00	(T 1.00	(T 1.00	(T 1.00	3.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
32B BUFFALO R.	(T 20.00	(T 1.00	(T 1.00	(T 1.00	5.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
32C BUFFALO R.	P40 40.00	(T 1.00	(T 1.00	(T 1.00	2.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
33A TWO MILE CR.	(T 20.00	2.00	(T 1.00	(T 1.00	5.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
33B TWO MILE CR.	P40 239.00	3.00	(T 1.00	(T 1.00	(T 5.00	(T 5.00	(T 1.00	3.00	(T 1.00
33C TWO MILE CR.	(T 163.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	3.00	(T 1.00
35A PETTIT FLUME	(T 20.00	634.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	8.00	(T 1.00
35B PETTIT FLUME	P40 55.00	600.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
35C PETTIT FLUME	P40 50.00	440.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	3.00	(T 1.00
38A GRATWICK-RIVERSIDE PARK	(T 20.00	3.00	(T 1.00	(T 1.00	(T 2.00	(T 5.00	(T 1.00	5.00	(T 1.00
38B GRATWICK-RIVERSIDE PARK	P40 60.00	3.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
38C GRATWICK-RIVERSIDE PARK	P40 50.00	2.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
39A WHEATFIELD	P40 60.00	3.00	(T 1.00	(T 1.00	2.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
39B WHEATFIELD	P40 60.00	2.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
39C WHEATFIELD	P40 100.00	5.00	(T 1.00	(T 1.00	4.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
40A 102ND ST.	P40 120.00	63.00	(T 1.00	(T 1.00	3.00	(T 5.00	4.00	3.00	(T 1.00
40B 102ND ST.	P40 100.00	52.00	(T 1.00	(T 1.00	2.00	(T 5.00	4.00	(T 1.00	(T 1.00
40C 102ND ST.	P40 110.00	60.00	(T 1.00	(T 1.00	(T 3.00	(T 5.00	(T 1.00	(T 2.00	(T 1.00

42A OCCIDENTAL SEWER 003	P40 372.00	29.00	(T 1.00	(T 1.00	46.00	100.00	(T 1.00	(T 2.00	(T 1.00
42B OCCIDENTAL SEWER 003	P40 180.00	17.00	(T 1.00	(T 1.00	10.00	185.00	(T 1.00	(T 7.00	(T 1.00
42C OCCIDENTAL SEWER 003	P40 414.00	15.00	(T 1.00	(T 1.00	46.00	215.00	(T 1.00	(T 2.00	(T 1.00
46A GILL CR.	P40 1120.0	28.00	(T 1.00	(T 1.00	30.00	(T 5.00	2.00	5.00	(T 1.00
46B GILL CR.	P40 813.00	65.00	(T 1.00	(T 1.00	17.00	(T 5.00	2.00	(T 2.00	(T 1.00
46C GILL CR.	P40 871.00	39.00	(T 1.00	(T 1.00	17.00	(T 5.00	5.00	5.00	(T 1.00
48A BLOODY RUN CR.	(T 20.00	30.00	(T 1.00	(T 1.00	6.00	(T 5.00	3.00	(T 2.00	(T 1.00
48B BLOODY RUN CR.	(T 20.00	47.00	(T 1.00	(T 1.00	5.00	(T 5.00	5.00	3.00	(T 2.00
48C BLOODY RUN CR.	(T 20.00	75.00	(T 1.00	(T 1.00	(T 4.00	(T 5.00	6.00	(T 4.00	(T 2.00
49A NIAGARA-ON-THE-LAKE	(T 20.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
49B NIAGARA-ON-THE-LAKE	(T 20.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00
49C NIAGARA-ON-THE-LAKE	(T 20.00	(T 2.00	(T 1.00	(T 1.00	(T 1.00	(T 5.00	(T 1.00	(T 1.00	(T 1.00

SAMPLING LOCATION	A-Chlordane	G-Chlordane	OP-DDT	PP-DDD	PP-DDT	Toxa-phene	Octachloro-styrene	Lipid (%)
1A WELLAND R. AT AIRPORT	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.34
1B WELLAND R. AT AIRPORT	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.95
1C WELLAND R. AT AIRPORT	(T 2.00	3.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.43
4A FALLS ST. TUNNEL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.40
4B FALLS ST. TUNNEL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	3.00	1.02
4C FALLS ST. TUNNEL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	5.00	1.54
5A MAID OF THE MIST POOL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.96
5B MAID OF THE MIST POOL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.91
5C MAID OF THE MIST POOL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.29
6A WELLAND R. AT POWER CANAL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.68
6B WELLAND R. AT POWER CANAL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.47
6C WELLAND R. AT POWER CANAL	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.82
9A CHIPPAWA CR. BELOW BLDG	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.28
9B CHIPPAWA CR. BELOW BLDG	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.92
9C CHIPPAWA CR. BELOW BLDG	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.09
10A LYONS CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.04
10B LYONS CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.91
10C LYONS CR.	(T 2.00	(T 2.00	(T 5.00	7.00	(T 5.00	(T 200.00	(T 1.00	1.93
12A USSHERS CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	2.01
12B USSHERS CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.84
12C USSHERS CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.65
15A BOYER'S CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.25
15B BOYER'S CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.44
15C BOYER'S CR.	(T 2.00	(T 2.00	(T 5.00	11.00	(T 5.00	(T 200.00	(T 1.00	1.37
17A BLACK CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.31
17B BLACK CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.04
17C BLACK CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.08
21A BAKER CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.90
21B BAKER CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.60
21C BAKER CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.65
24A MILLER CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.00
24B MILLER CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.02
24C MILLER CR.	(T 2.00	(T 2.00	(T 5.00	11.00	(T 5.00	(T 200.00	(T 1.00	0.64

27A FRENCHMAN'S CR.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.83
27B FRENCHMAN'S CR.	<T 2.00	<T 2.00	<T 5.00	6.00	<T 5.00	<T 200.00	<T 1.00	1.09
27C FRENCHMAN'S CR.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.96
29A FRENCHMAN'S CR. AT DUREZ	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.73
29B FRENCHMAN'S CR. AT DUREZ	4.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.08
29C FRENCHMAN'S CR. AT DUREZ	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.55
30A FORT ERIE AT ROBERTSON ST.	<T 2.00	<T 2.00	<T 5.00	7.00	<T 5.00	<T 200.00	<T 1.00	1.01
30B FORT ERIE AT ROBERTSON ST.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.63
30C FORT ERIE AT ROBERTSON ST.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.70
31A THUNDER BAY, L. ERIE	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.79
31B THUNDER BAY, L. ERIE	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.40
31C THUNDER BAY, L. ERIE	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.89
32A BUFFALO R.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.78
32B BUFFALO R.	<T 2.00	<T 2.00	<T 5.00	7.00	<T 5.00	<T 200.00	<T 1.00	0.78
32C BUFFALO R.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	0.84
33A TWO MILE CR.	<T 2.00	<T 2.00	<T 5.00	8.00	<T 5.00	<T 200.00	<T 1.00	0.91
33B TWO MILE CR.	5.00	<T 2.00	<T 5.00	12.00	<T 5.00	<T 200.00	<T 3.00	1.03
33C TWO MILE CR.	4.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.27
35A PETTIT FLUME	7.00	6.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.06
35B PETTIT FLUME	6.00	3.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	3.00	1.41
35C PETTIT FLUME	6.00	3.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	2.00	0.79
38A GRATWICK-RIVERSIDE PARK	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	3.00	0.90
38B GRATWICK-RIVERSIDE PARK	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.29
38C GRATWICK-RIVERSIDE PARK	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.93
39A WHEATFIELD	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.19
39B WHEATFIELD	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.18
39C WHEATFIELD	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 2.00	1.69
40A 102ND ST.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	3.00	1.26
40B 102ND ST.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	2.00	1.21
40C 102ND ST.	<T 2.00	<T 2.00	<T 5.00	<T 5.00	<T 5.00	<T 200.00	<T 1.00	1.98

42A OCCIDENTAL SEWER 003	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	2.00	1.49
42B OCCIDENTAL SEWER 003	3.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.29
42C OCCIDENTAL SEWER 003	4.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 285.00	10.00	1.36
46A GILL CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	15.00	1.39
46B GILL CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	140.00	1.08
46C GILL CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	90.00	0.82
48A BLOODY RUN CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.79
48B BLOODY RUN CR.	(T 2.00	(T 3.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.89
48C BLOODY RUN CR.	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 3.00	1.23
49A NIAGARA-ON-THE-LAKE	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.15
49B NIAGARA-ON-THE-LAKE	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	0.74
49C NIAGARA-ON-THE-LAKE	(T 2.00	(T 2.00	(T 5.00	(T 5.00	(T 5.00	(T 200.00	(T 1.00	1.25

Appendix Table 5.

NIAGARA RIVER BIOMONITORING STUDY, 1987
Chlorophenols in Leeches
(ng/g Wet Weight)

SAMPLING LOCATION	REP	2,4,6 Tri-Chlorophenol	2,4,5 Tri-Chlorophenol	2,3,4 Tri-Chlorophenol	2,3,5,6 Tetra-Chlorophenol	2,3,4,5 Tetra-Chlorophenol	Penta-Chlorophenol	Lipid (%)
CONTROL	A	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.2
CONTROL	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	60.0	1.4
CONTROL	C	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.3
38A GRATWICK-REVERSIDE PARK	A	<T 50.0	200.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.0
38B GRATWICK-RIVERSIDE PARK	A	70.0	240.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.1
38C GRATWICK-RIVERSIDE PARK	B	<T 50.0	220.0	<T 100	<T 50.0	<T 50.0	375.0	0.9
39A WHEATFIELD	A	<T 50.0	330.0	<T 100	<T 50.0	<T 50.0	<T 50.0	0.7
39B WHEATFIELD	B	<T 50.0	240.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.5
39C WHEATFIELD	C	<T 50.0	220.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.3
40A 102ND ST.	A	90.0	270.0	<T 100	<T 50.0	<T 50.0	65.0	1.0
40B 102ND ST.	B	80.0	290.0	<T 100	<T 50.0	<T 50.0	65.0	1.2
40C 102ND ST.	C	120.0	380.0	<T 100	<T 50.0	<T 50.0	80.0	1.3
49A NIAGARA-ON-THE-LAKE	A	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.3
49B NIAGARA-ON-THE-LAKE	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.3
49C NIAGARA-ON-THE-LAKE	C	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.2
4A FALLS ST. TUNNEL	A	310.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.1
4B FALLS ST. TUNNEL	B	340.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	0.3
4C FALLS ST. TUNNEL	C	280.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.3
5A MAID OF THE MIST POOL	A	80.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.0
5B MAID OF THE MIST POOL	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.4
5C MAID OF THE MIST POOL	C	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	1.0
27A FRENCHMAN'S CR.	A	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	100.0	0.8
27B FRENCHMAN'S CR.	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	110.0	1.1
27C FRENCHMAN'S CR.	C	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	0.9
29A FRENCHMAN'S CR. AT DUREZ	A	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	350.0	0.9
29B FRENCHMAN'S CR. AT DUREZ	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	55.0	1.0
29C FRENCHMAN'S CR. AT DUREZ	C	85.0	<T 50.0	<T 100	<T 50.0	<T 50.0	110.0	1.4
30A FORT ERIE AT ROBERTSON ST.	A	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	0.8
30B FORT ERIE AT ROBERTSON ST.	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	0.8
30C FORT ERIE AT ROBERTSON ST.	C	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	<T 50.0	0.8
32A BUFFALO CR.	A	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	66.0	1.2
32B BUFFALO CR.	B	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	130.0	1.0
32C BUFFALO CR.	C	<T 50.0	<T 50.0	<T 100	<T 50.0	<T 50.0	130.0	1.0
35A PETTIT FLUME	A	1040.0	130.0	140.0	220.0	<T 50.0	230.0	1.2
35B PETTIT FLUME	B	<T 50.0	<T 50.0	100.0	<T 50.0	55.0	<T 50.0	1.0
35C PETTIT FLUME	C	4080.0	310.0	310.0	385.0	110.0	560.0	0.9

[redacted] <T [redacted]LOW [redacted]REM[redacted]S TE[redacted]VE. [redacted]INF[redacted]Y [redacted]

Appendix Table 6. NIAGARA RIVER BIOMONITORING STUDY 1987
PAHs in Mussels
(ng/g wet weight)

SAMPLING LOCATION	Naphthal	Acenaphthy	Acenaphth	Fluorene	Phenanth	Anthracene	Fluoran	Pyrene	B(a)A	Chrysene	B(b)F	B(k)F	B(a)P	Indeno-	Dibenz(ah)A	Benz(ghi)
1A WELLAND R. AT AIRPORT	10.00	10.00	10.00	10.00	10.00	10.00	31.40	31.40	10.00	10.00	32.40	10.00	20.00	20.00	20.00	20.00
1B WELLAND R. AT AIRPORT	10.00	10.00	10.00	10.00	10.00	10.00	25.70	32.70	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
1C WELLAND R. AT AIRPORT	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
4A FALLS ST. TUNNEL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
4B FALLS ST. TUNNEL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
4C FALLS ST. TUNNEL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
5A MAID OF THE MIST POOL	21.00	10.00	10.00	10.00	10.00	10.00	25.20	24.30	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
5B MAID OF THE MIST POOL	10.00	10.00	10.00	20.50	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
5C MAID OF THE MIST POOL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
6A WELLAND R. AT POWER CANAL	10.00	10.00	10.00	10.00	10.00	10.00	24.60	37.80	10.00	27.30	10.00	10.00	10.00	20.00	20.00	20.00
6B WELLAND R. AT POWER CANAL	10.00	10.00	10.00	10.00	10.00	10.00	10.00	31.20	10.00	23.90	10.00	10.00	10.00	20.00	20.00	20.00
6C WELLAND R. AT POWER CANAL	10.00	10.00	10.00	10.00	10.00	10.00	24.30	41.60	10.00	24.60	10.00	10.00	10.00	20.00	20.00	20.00
9A CHIPPAWA CR. BELOW BLOB	10.00	10.00	10.00	40.60	64.70	10.00	111.40	81.00	31.10	34.60	40.10	10.00	28.90	20.00	20.00	20.00
9B CHIPPAWA CR. BELOW BLOB	10.00	10.00	10.00	31.00	58.70	10.00	129.40	97.40	10.00	33.00	22.40	10.00	10.00	20.00	20.00	20.00
9C CHIPPAWA CR. BELOW BLOB	10.00	10.00	10.00	31.40	88.70	27.60	148.80	118.20	66.40	64.70	98.70	10.00	49.40	20.00	20.00	20.00
10A LYONS CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
10B LYONS CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
10C LYONS CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
12A USSHERS CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
12B USSHERS CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
12C USSHERS CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
15A BOYER'S CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
15B BOYER'S CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
15C BOYER'S CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
17A BLACK CR.	20.50	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
17B BLACK CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
17C BLACK CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
21A BAKER CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	46.60	20.00
21B BAKER CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
21C BAKER CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
24A MILLER CR.	10.00	78.20	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
24B MILLER CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	83.50	20.00
24C MILLER CR.	10.00	45.30	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	56.80	20.00
27A FRENCHMAN'S CR.	10.00	10.00	10.00	31.10	10.00	10.00	24.90	10.00	10.00	21.30	10.00	10.00	10.00	20.00	102.30	20.00
27B FRENCHMAN'S CR.	10.00	35.00	10.00	27.70	10.00	10.00	24.80	10.00	10.00	10.00	10.00	10.00	10.00	20.00	71.40	20.00
27C FRENCHMAN'S CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	93.70	20.00
29B FRENCHMAN'S CR. AT DUREZ	10.00	10.00	32.90	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
29C FRENCHMAN'S CR. AT DUREZ	39.80	93.20	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
30A FORT ERIE AT ROBERTSON ST.	10.00	10.00	32.90	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
30B FORT ERIE AT ROBERTSON ST.	39.20	117.60	24.90	10.00	10.00	10.00	27.80	10.00	10.00	10.00	24.10	10.00	10.00	20.00	20.00	20.00
30C FORT ERIE AT ROBERTSON ST.	40.80	150.10	29.70	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
31A THUNDER BAY, L. ERIE	49.40	145.80	29.90	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
31B THUNDER BAY, L. ERIE	27.70	123.00	25.60	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
31C THUNDER BAY, L. ERIE	34.90	189.60	41.10	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00

32A BUFFALO R.	22.00	105.10	21.20	10.00	10.00	10.00	45.30	152.10	10.00	61.90	40.00	10.00	10.00	20.00	20.00	20.00
32B BUFFALO R.	10.00	10.00	10.00	10.00	10.00	10.00	47.00	138.90	21.90	63.50	75.10	10.00	10.00	20.00	20.00	20.00
32C BUFFALO R.	10.00	10.00	10.00	10.00	10.00	10.00	44.10	123.70	24.00	59.20	64.00	10.00	10.00	20.00	20.00	20.00
33A TWO MILE CR.	10.00	10.00	10.00	32.10	191.10	10.00	242.80	222.30	10.00	162.80	199.40	10.00	10.00	20.00	20.00	20.00
33B TWO MILE CR.	10.00	10.00	10.00	47.30	274.30	10.00	336.80	297.20	32.10	203.00	276.30	10.00	10.00	20.00	20.00	20.00
33C TWO MILE CR.	10.00	10.00	10.00	64.10	323.50	10.00	435.80	404.00	50.70	307.10	413.90	10.00	23.90	20.00	20.00	20.00
35A PETTIT FLUME	10.00	10.00	10.00	10.00	90.90	10.00	290.90	278.60	66.10	234.90	216.30	10.00	38.30	20.00	20.00	20.00
35B PETTIT FLUME	10.00	10.00	10.00	45.00	252.80	30.20	542.30	498.00	79.90	292.30	201.90	10.00	45.00	20.00	20.00	20.00
35C PETTIT FLUME	10.00	10.00	10.00	10.00	100.30	10.00	345.20	356.00	44.70	233.70	151.60	10.00	23.30	20.00	20.00	20.00
38A GRATWICK-RIVERSIDE PARK	10.00	10.00	10.00	10.00	10.00	10.00	37.50	41.40	10.00	41.20	59.10	10.00	10.00	20.00	20.00	20.00
38B GRATWICK-RIVERSIDE PARK	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	27.70	10.00	10.00	10.00	20.00	20.00	20.00
38C GRATWICK-RIVERSIDE PARK	10.00	10.00	10.00	10.00	10.00	10.00	40.00	45.30	10.00	42.60	30.60	10.00	20.50	20.00	20.00	20.00
39A WHEATFIELD	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
39B WHEATFIELD	10.00	10.00	10.00	10.00	10.00	10.00	20.20	26.00	10.00	29.20	21.70	10.00	10.00	20.00	20.00	20.00
39C WHEATFIELD	10.00	10.00	10.00	10.00	10.00	10.00	47.60	52.90	22.70	57.40	57.80	10.00	20.50	20.00	20.00	20.00
40A 102ND ST.	10.00	10.00	10.00	10.00	22.30	10.00	39.20	37.00	10.00	39.20	32.50	10.00	10.00	20.00	20.00	20.00
40B 102ND ST.	10.00	10.00	10.00	10.00	21.00	10.00	31.60	29.80	10.00	32.30	28.90	10.00	10.00	20.00	20.00	20.00
40C 102ND ST.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	24.10	10.00	10.00	10.00	20.00	20.00	20.00
42A OCCIDENTAL SEWER 003	10.00	10.00	10.00	10.00	29.70	10.00	160.30	181.80	88.50	157.80	187.20	10.00	40.10	20.00	20.00	20.00
42B OCCIDENTAL SEWER 003	10.00	10.00	10.00	10.00	27.80	10.00	105.80	129.70	73.60	109.50	164.70	10.00	39.30	20.00	20.00	20.00
42C OCCIDENTAL SEWER 003	10.00	10.00	10.00	10.00	40.20	10.00	219.90	261.70	130.30	217.40	326.00	10.00	82.70	20.00	20.00	20.00
46A GILL CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
46B GILL CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
46C GILL CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
48A BLOODY RUN CR.	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	22.40	10.00	10.00	10.00	20.00	20.00	20.00
49A NIAGARA-ON-THE-LAKE	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
49B NIAGARA-ON-THE-LAKE	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00
49C NIAGARA-ON-THE-LAKE	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	20.00

NOTE: 20 ng/g DETECTION LIMIT FOR ALL PAH EXCEPT INDENO[123-cd]PYRENE, DIBENZ[ah]A AND BENZ[ghi]PER WHICH ARE 40 ng/g.
HALF THE DETECTION LIMIT IS REPORTED FOR CONTAMINANTS AT OR BELOW DETECTION.